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.

Right and opposite Shooting square to the subject overcomes some of the problems with the limited depth-of-field in close-up photography. Much of the dragonfly is sharp in both photographs. They were taken using the EF 12 and EF 25 extension tubes mounted together on an EF 70-200mm f2.8L IS USM lens. The main light is from a Speedlite fired through a diffuser to avoid hotspots on the delicate wings. Slow shutter speeds pick up the ambient light. *Right* 1/15 second at f16, ISO 400. *Opposite* 1/10 second at f16, ISO 100. Both with EOS 5D Mk II.

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.

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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.

Above Canon extension tube EF 25 II fitted between an EOS camera and an EF 50mm f1.8 lens.

Current extension tubes EF 25 II and EF 12 II

Discontinued extension tubes EF 25 and EF12

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Extension tubes in action

The magnification formula

There is a formula for working out how much magnification extension tubes will give you:
magnification = extension/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 and magnification of a lens, figures that Canon do publish. Let's take Canon's EF 50mm f1.8 II lens, as an example. We know the focal length (50mm) and Canon gives the magnification as 0.15x (this is at the minimum focusing distance of 45cm). From these figures a little algebra reveals that the effective extension built into the lens is 7.5mm (extension = magnification x focal length).

We use the phrase 'effective' extension because the focal length of the lens can change slightly at different focusing distances.

Adding the EF 25 II extension tube to the lens gives a total extension of 32.5mm. To work out the magnification, just divide the extension (32.5mm) by the focal length (50mm) to give a figure of 0.65x.

It's much easier to judge magnification with some practical examples. The photos on the right show how much magnification you can obtain with certain 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.

Minimum focusing distances				
Extension tubes	Lens			
	17-40mm f4L at 40mm	50mm f1.4	85mm f1.8	70-210 f4L IS at 210mm
None	28cm	45cm	85cm	120cm
EF12 / EF12 II	23cm	27cm	51cm	102cm
EF25 / EF25 II	22cm	22cm	41cm	90cm
EF12 + EF25 or EF12 II + EF25 II	N/A*	21cm	37cm	62cms

* Lens cannot focus on the subject at this extension.

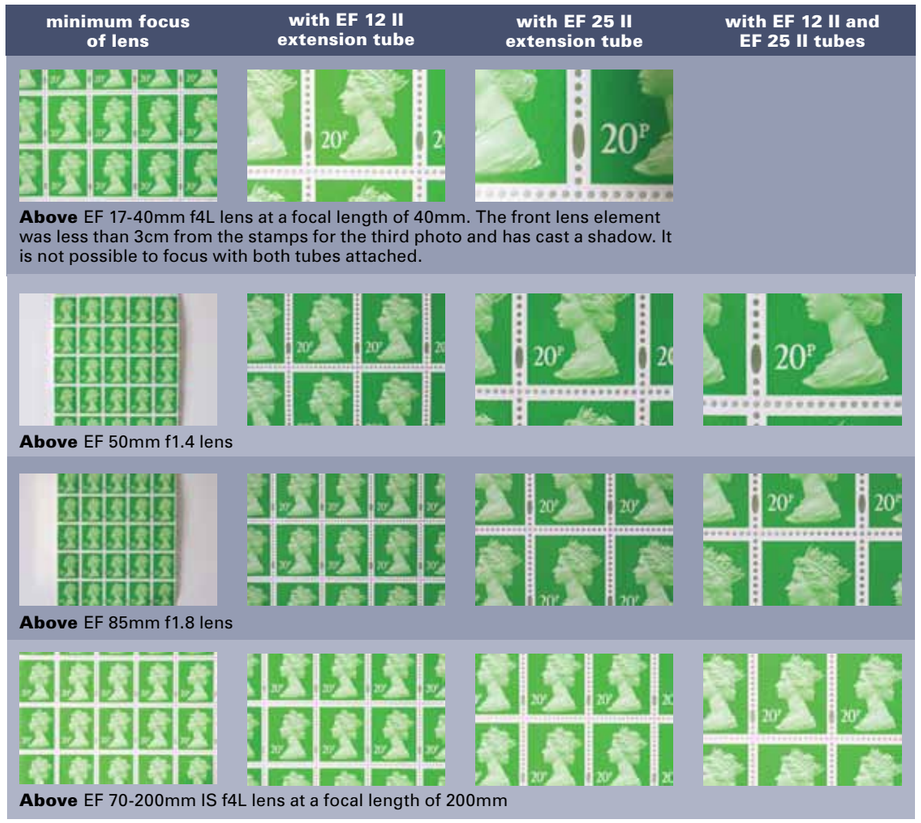
Extension tubes	Lens compatibility	Approximate retail price*	Extension	Recommended focal lengths
EF12	EF, TS-E lenses	discontinued	12mm	24-100mm
EF25			25mm	50-150mm
EF12 II	EF, EF-S, TS-E lenses	£71.99	12mm	24-100mm
EF25 II		£99.99	25mm	50-150mm

* Varies by dealer.

Unsuitable lenses

The EF 14mm, and EF 15mm lenses are unsuitable for the EF12/EF12 II extension tubes. These lenses, plus the EF 20mm and EF 24mm are unsuitable for the EF25/EF25 II extension tubes. Zoom lenses at these focal lengths are also unsuitable.

Tube magnification



Above EF 17-40mm f4L lens at a focal length of 40mm. The front lens element was less than 3cm from the stamps for the third photo and has cast a shadow. It is not possible to focus with both tubes attached.

Above EF 50mm f1.4 lens

Above EF 85mm f1.8 lens

Above EF 70-200mm IS f4L lens at a focal length of 200mm

Left The effectiveness of adding extension tubes depends on the focal length of the lens. The shorter the focal length, the greater the effect. The 17-40mm lens has the greatest magnification, but with a gap of less than 3cm between the lens element and the subject when used with the EF 25 II, it is impractical to use at this high level of magnification as the lens blocks the light.

The 50mm and 85mm lenses give more practical working distances and good magnification, especially when the two extension tubes are combined.

The 70-200mm lens does not benefit as much from the extension tubes. If you have this focal length lens, the 500D or 250D close-up lenses will give you greater magnifications.

All photos taken with an EOS 40D.

Crop 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 life 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 15 x 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.

Right The top picture shows the image captured by a full-frame sensor. The white rectangle shows the area seen by an APS-C sensor. (Assuming the same lens is used on each camera to take the picture.) Both images have the same magnification. However, if you want both images to fill the same print area, the APS-C image has to be enlarged more than the full frame image. The result is that th APS-C camera appears to give greater magnification.

Above This photo was taken with an EF 85mm f1.8 lens on an EOS 40D. The lens was set to its minimum focusing distance of 85cm. This photo is as close as the photographer can get with this lens.

Above This photo was taken with the same 85mm lens focused at its minimum focus setting, and with the EF 12 extension tube fitted. However, instead of focusing at 85cm, the lens can now focus at a distance of approximately 53cm from the subject.

Above The 85mm lens was focused at its minimum focusing distance. With the EF 25 extension tube fitted, the photographer could move within 39cm of the subject.

Right The EF 25 and EF 12 extension tubes were combined, giving a total extension of 37mm. The 85mm lens was set to its minimum focusing distance, enabling a sensor plane to subject distance of 34cm.

Focus stacking

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 front to 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.

Above A different part of the flower is in focus in each of the photos. The focus stacking technique blends them all together to create a new image comprising the sharp zones in each photo (see main image).

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 the 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 $30US, and you can download the program and try it for 30 days without any restrictions.

We tested Adobe Photoshop CS4 and Helicon Focus. Both programs worked flawlessly – Helicon Focus was much quicker and easier to use, but cropped tighter into the image than Photoshop CS4.

Focus stacking in Photoshop

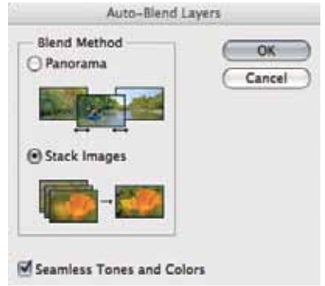
1 If you shot the photos in RAW, process them identically in Digital Photo Professional (DPP) or other RAW conversion software.

2 DPP users: Go to File > Batch Process and save the images in the JPEG format in a new folder (set Image quality to 10).

3 Open Adobe Bridge, navigate to the new folder and select all the images (Edit > Select all).

4 Go to Tools > Photoshop > Load files into Photoshop layers. This loads the selected photos into Photoshop CS 4 and combines them into a single file with each photo in its own layer.

5 The photos need to be aligned. Each photo is slightly different, as at such close lens-to-subject distances the effective focal length of the lens changes when you focus on different points. To fix this, go to Select > All layers then Edit > Auto-Align Layers... Select 'Auto' and press OK. Photoshop aligns the layers.



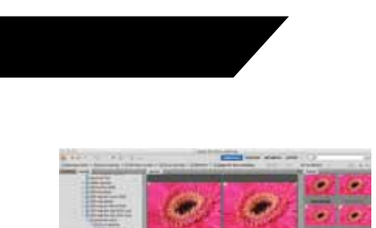
6 To blend the sharp parts of the layers together, go to Edit > Auto-Blend Layers, Select 'Stack Images' and tick 'Seamless Tones and Colours' then press OK. It will take a few minutes. When done, go to Layer > Flatten Image to flatten the layers and then save the photo.

Helicon Focus

Helicon Focus is very easy to use. Start by clicking the Add Images button to load your photos and clear any other images already there. Press the Render button (you can play with focus parameters, but the default ones worked fine for us) and then the Saving button to save the image once the blending process has finished.

As far as we know, focus stacking is exclusive to digital photography. Unlike many other digital techniques, it does not appear to be an implementation of a film technique. It is not the answer to every depth-of-field issue, but it will solve a few tricky problems.

Focus stacking tips



- **Use a tripod and cable release to keep the camera in the same position for every shot. Be careful not to jog the tripod.**
- **Avoid camera shake caused by camera vibration at slow shutter speeds by enabling the mirror lock-up in the Custom Functions menu.**
- **Take two exposures at each setting when using slow shutter speeds as insurance against any spoilt by camera shake.**
- **Use ISO 100 for maximum image quality and colour saturation, or a high ISO like 1600 or 3200 for a grainy effect caused by noise.**
- **Use the Quick Control screen, if your camera has it. It is much easier to see your aperture, shutter speed and ISO settings here than on the LCD panel on top of the camera.**
- **If you have more than one EOS camera, try using the one with fewer megapixels. This produces smaller files, which are easier for your computer to handle, particularly if you are blending a lot of photos or have a slow computer.**
- **Shoot RAW + JPEG, and make sure that you set the Picture Style, white balance, aperture and shutter speed manually. Shoot each photo at the same ISO, aperture and focal length. If your settings are accurate, you can blend the JPEG files straight out of the camera, and you have the RAW files as insurance in case you need to tweak any settings afterwards.**

Rodel Manabat

Case studies

May-lin Joe

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 is 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.

I set the focusing to manual or automatic depending on the subject. If the subject is moving (such as insect, flower, plant, droplets on leaves) then it is better to focus manually.

If your subject is fixed you can mount your camera on a tripod, set autofocus and use a shutter release cable to minimize camera shake. I prefer to use a wider aperture (f2.8 to f4) to draw attention to only a portion of the subject. I use selective focusing from the 9 autofocus points of my camera. If there is too much movement in the subject AI focusing is of great advantage.

Flash is important. I used to ignore using the camera's built-in flash, but after colleagues showed me the advantage of using flash it has now become part of my set-up. I also use a Speedlite 580EX II with a Stofen OmniBounce diffuser.

The photos on this page were taken using an EF 24-70mm lens set to 70mm and fitted with an EF12 II extension tube. The depth-of-field is very narrow but Rodel has used this limitation to great creative effect.
Above *EOS 40D, EF 24-70mm f2.8L lens with EF 12 II Extension tube, ISO 100, f2.8, 1/40 second.*
Right *EOS 40D, EF 24-70mm f2.8L lens with EF 12 II Extension tube, ISO 400, f2.8, 1/200 second.*

Both Rodel and May-lin can be found online at Flickr. You can view their galleries at ***www.flickr.com/photos/rodjbman71*** *and* ***www.flickr.com/photos/mayj*** *respectively.*

For my water droplet photos I use an EF 100mm Macro lens with an EF 25 II extension tube and manual focus to get the biggest, clearest droplet possible. I always use a tripod and work with natural light.

I shoot my water drop shots indoors as it's usually somewhat breezy where I live, but I have good light from large windows. I set up the flower with the background positioned between 6 to 12 inches behind it, depending on the desired result.

I place the water droplet on the petal with a syringe and adjust the background so that I can see it in the drop. It can be a little time consuming, even frustrating, to get a drop to a nice shape and make it stay in place. The droplet has to be positioned to get an unobscured view of the background.

Sometimes I use printed matter such as gift wrap or greeting cards to produce the refracted image in the water droplet. Designs with bright clear colours give the clearest refractions. The image will be inversed in the water drop. I position the background sheet upside down so that the design shows the right way up in the refraction. I also like to use flowers – again the brightest coloured flowers make the clearest images.

Tube pros and cons

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.

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.

You don't have this problem if 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.

Above The effectiveness of adding extension tubes depends on two factors – the focal length of the lens and the minimum focusing distance. The shorter the lens, and the closer its minimum focal distance, the greater the level of magnification will be gained from adding an extension tube.

Third party

EOS-fit extension tubes are made by other companies and are less expensive than those from Canon. However, the build quality can be inferior and we have not come across any that are compatible with EF-S lenses. Canon extension tubes maintain full electrical contact between the camera body and lens, so that you can stop down the aperture and, if you want to, use autofocus. It is possible to buy extension tubes for under £10, but the catch is that they have no electrical contacts. You cannot stop down your lens and use a small aperture as EF lenses do not have manual aperture rings. This means that you will be limited to using your lens at its widest aperture, unable to increase the depth-of-field.