



Photography 101

Each issue of PhotographyBB Online Magazine will bring you helpful tips and tutorials on how to get the most of your digital camera and equipment. We'll cover camera techniques, principals of photography, digital photography issues, and how to get the most from the dreaded manual-mode!

UNDERSTANDING LENSES, FOCAL LENGTHS, CROP FACTORS AND MORE - By Colin Bell

This article focuses on two important parts of the digital camera system – the lens and the image sensor. In the world of digital photography, there are times when it is important to consider these together, especially when it comes to talking about how close you can zoom in on a scene.

When you look at any lens on a camera, the first thing you will notice is that it will have a certain focal length (or range of focal lengths in the case of a zoom lens). The principle purpose for changing the focal length of a lens is to change the angle of view. A smaller focal length will capture more of the scene (have a greater angle of view) than a higher focal length. However the actual angle captured in your final picture is also influenced by the size of the image sensor. A 50mm lens will have a wider angle of view on a camera with a large image sensor than it will on a camera with a small sensor. To help explain this, take a look at the following picture.



The picture shows the image circle cast by the lens onto the focal plane (the back of the camera where the sensor sits). The red rectangle represents the size of a full frame sensor or a frame on 35mm film. You can see that this lens has been designed to cast an image circle just big enough to cover the whole of the image sensor.

If you put this same lens onto a camera which has a smaller sensor (a typical APS-C sized sensor is represented by the blue rectangle), it will only 'see' the middle part of the image – you could say it has been cropped compared with the image from the full frame sensor camera.

If you print both the images at 6x4 inches (150x100mm) say, you'd get the following two images:



Photo 1 - Image from a full frame camera.



Photo 2 - Image from a small sensor camera with the same lens.

Now normally if I was explaining this concept to someone, I would leave it at that. However I am writing this for a target audience that I'm sure will want the full picture so I am going to complicate matters further by introducing another term - **magnification**. The magnification of a lens is the same no matter what camera you put it on. This seems to contradict what I mentioned at the beginning about the reach (or angle of view) of a lens being dependent on the lenses focal length AND the size of the image sensor. However magnification is a function of the lens ONLY and therefore is not the same as the angle of view.

Confused? Take a look at the following two images showing how photos 1 and 2 (from the previous page) appear on their respective sized sensors. I've drawn a 35mm negative frame around them to give you a scale reference.



The one on the left is full frame, the one on the right is the smaller sensor. You can see that with the smaller sensor, you are getting less of the scene in your final picture (photo 2), but the magnification is the same. Just compare the actual size of the sand buggy in both pictures and you'll see they are identical.

But when you compare the two final 6x4 prints (photos 1 and 2), there is clearly a difference in magnification. The reason for this is that printing the 6x4s involves a greater amount of enlargement for photo 2. Photo 1 was enlarged from a 36x24mm FF sensor up to the 150x100mm print (about 4.2x enlargement) – but the print from the smaller sensor camera has been enlarged from a 23.6x15.8mm sensor (about a 6.4x enlargement). It is only in making the print that the magnification changes.

Equivalent Focal Lengths

As 35mm film has been in existence for a long time, photographers got used to what angle of view corresponded to a particular focal length – everyone knew a 28mm was a wide angle lens and a 50mm was your 'normal' lens. Because of this familiarity with the 35mm film format, the crop factor is sometimes known as a focal length multiplier (FLM). I don't like this term as it assumes that 35mm/full frame is some divine format that everything should be referenced to and that the focal length changes depending on the camera the lens is attached to. In reality, a 50mm lens is always a 50mm lens whether it's on a full frame or crop sensor camera - it's just the angle of view that changes. So the 50mm lens which is your 'normal' lens on a film camera becomes a short telephoto lens on a smaller sensor camera.

I exclusively use DSLRs with crop sensors and now find it easier to think in terms of actual focal lengths and not equivalent 35mm focal lengths. For example if you own a Canon, Nikon, Sony or Pentax, think of 18mm as wide angle, 35mm as your standard lens and 70mm as your portrait lens (and not 28mm, 50mm and 105mm as you might have in the days of film).

With compact cameras however, it is common to talk about the 35mm equivalent zoom range as the physical sensor size can vary greatly from one camera to another. Doing this removes sensor size out of the equation, and makes it easier to compare one compact camera to another. For example a Fuji S9100/S9600 has a focal range of 6.3mm to 67mm, whereas a Canon SX100 IS has a focal length range of 6.0mm to 60mm. So does the Canon give the wider field of view? Without knowing the size of the sensor, you just can't tell. As it happens the Fuji's lens is a 28-300mm equivalent (crop factor of 4.48) and the Canon's is 36-360mm (crop factor of 6.0 due to very small sensor).

If you must continue to use 35mm equivalents and want to buy a lens for your DSLR which give you what you used to know as an x mm lens on your old film SLR, you should divide by your cameras crop factor. As an example, for a Canon EOS 40D with a 1.6x crop factor - if you want a lens the same as your old 24mm ultra-wide film lens, you will need a $24\text{mm}/1.6 = 15\text{mm}$ lens on a Canon EOS 40D.

Digital Lenses

Another common source of confusion is with digital only lenses (such as Canon's EF-S range, Nikon's DX lenses, Sigma DC lenses or Tamron Di-II lenses). Users sometimes think that, as they are designed specifically for smaller sensor cameras, you don't need to multiply it by anything to get the 35mm equivalent focal length. This is wrong – as I stated above the focal length of a lens does not change when you put it on a small-sensor camera. So for example Canon and Sigma both make a 55-200mm lens – the Canon is a full frame lens whereas the Sigma is a digital only. Put them on a crop sensor camera and the zoom capability of both is exactly the same.

So what is the difference between a normal (full frame) lens and a digital only lens? Well look at these two images – the one on the left shows the image cast by a full frame lens, the one on the right by a digital only lens of the same focal length.



The red and blue rectangles still represent the full frame and APS-C sensor sizes respectively. You can see that with the digital lens, the image circle is much smaller. It is designed to be just large enough to cover the smaller sensor. If you were to put this on a full frame camera (assuming it would allow you), the resulting image would be a circle in the middle of the frame. In fact, Canon has changed the mount to prevent you from attaching their digital lenses onto one of their full frame / film cameras.

The advantage of creating a lens that projects a smaller image circle is that the lens elements can be much smaller and therefore lighter, allowing the creation of much more compact and portable lenses. They are also sometimes built to be telecentric – meaning that light hits the image sensor at close to right angles and in theory, gives a more even brightness across the frame. *{Note: A telecentric lens requires the lens mount must be around twice*

the size of the image circle and therefore is currently only implemented on the smaller four-thirds type image sensor used on all Olympus cameras}

Common Sensor sizes and their Crop Factors:

Sensor Size (mm)	Name	Crop Factor	Some Cameras that use this...
36.0 x 24.0	Full Frame	1.0	Canon EOS 5D, 1Ds Nikon D3, D3X D700, Sony a900
28.7 x 19.1	APS-H	1.25	Canon EOS 1D
27.0 x 18.0	Leica	1.33	Leica M8, M8.2
23.6 x 15.8 (approx)	APS-C	1.5	Nearly all Nikon DSLRs, Sony and Pentax are very similar in size
22.2 x 14.8	APS-C	1.6	Most Canon DSLRs inc. 350D, 400D, 450D, 20D, 30D, 40D, 50D
18.0 x 13.5	Four-Thirds	2.0	All Olympus and Panasonic DSLRs
18.0 x 13.5	Micro Four-Thirds	2.0	Panasonic DMC-G1 and GH1
Various	Compact	4.5 - 6.5	Majority of Compact Cameras

A finishing thought ...

If you ever come across any full frame snobs bragging about how APS-C can't compete with their 'full-frame' camera, just tell them that they too have a crop-sensor camera when compared with your Hasselblad or Phase One medium format camera you have back at the house!

About Colin Bell:

Colin Bell is an enthusiastic amateur photographer that works in the IT business. Colin works as a software developer for an environmental research institute and is a specialist in tidal theory and marine software. Colin has had an interest in photography since 1984 when he received a Chinon CE-4 one Christmas. In 1991 he upgraded to a Pentax P30T and spent a lot of time shooting black & white film and developing it in his loft based darkroom. He bought his first digital camera in 1999 (a 0.8 Megapixel Fuji DX-10) and now uses a Canon EOS 350D and 40D.

For more information and digital photography tutorials, techniques and tips, visit Colin Bell at his website at: <http://www.creativephotobook.co.uk>