ISO, Aperture and Shutter Speed
A Balancing Act

Bob Holder

When moving away from fully automatic, the confusion that comes with setting the correct alignment of ISO, Aperture and Shutter Settings to create a good exposure is well-known. As each one depends upon the setting of the other to make such a good exposure, understanding what each one does is essential. This article aims to clear up the puzzle the required settings cause.

Here we will look at the two highest-used semi-automatic modes: Aperture Priority (A or Av) and Shutter Priority (S or Tv). Full manual mode will develop on from a use of these semi-automatic modes. As full manual mode is usually used in a controlled environment (for example, a studio), unless this is to be of prime interest to you, it will be discussed in a separate article. Let's start with the basics…

ISO

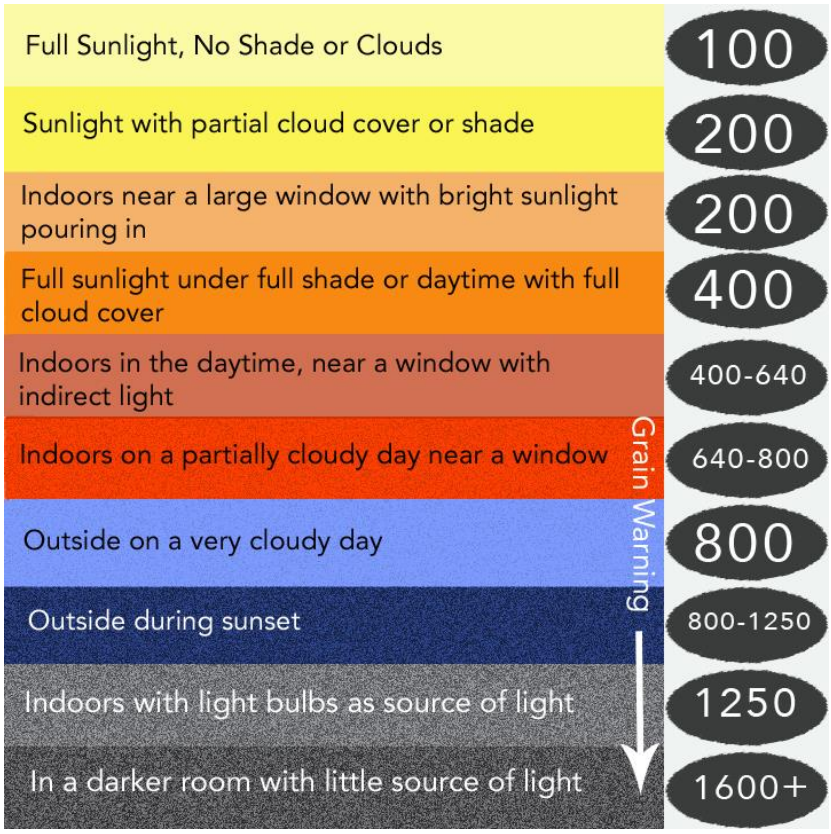
This is probably the hardest part of photography to understand. In loose terms, ISO refers to the sensitivity of the camera's sensor to light. The range of sensitivity of a camera sensor may run from ISO 100 up to ISO 6400 The prime values generally double a lower value, or half a higher value – that is to say the corresponding range might look like this:

100	**Plenty of available light**
200	
400	
800	**Not much available light**
1600	
3200	
6400	**Very low available light**

These are the basic settings; most cameras, be they phone or tablet, compact camera, or DSLRs may have intermediate, and higher or lower values than the basic range shown here. Take a moment to look at your camera's manual to see how high or low your camera sensor can adjust to the light, and the ISO settings it uses. The higher the ISO value, the lower the available light can form an image on the sensor and still give a reasonable exposure; the lower the ISO value, the better the colour saturation and vibrance. This ISO value can be set in either Aperture or Shutter Priority modes, and will be defined by the situation where the shot is to be taken. The lower the available light, the higher the ISO setting is needed.

Generally, shots taken on a bright sunny day will be taken with a lower ISO, while shots taken in a dark room or church (when flash is often not allowed) require a higher ISO value, to allow the sensor to "see" the subject.

Typical ISO settings could be:

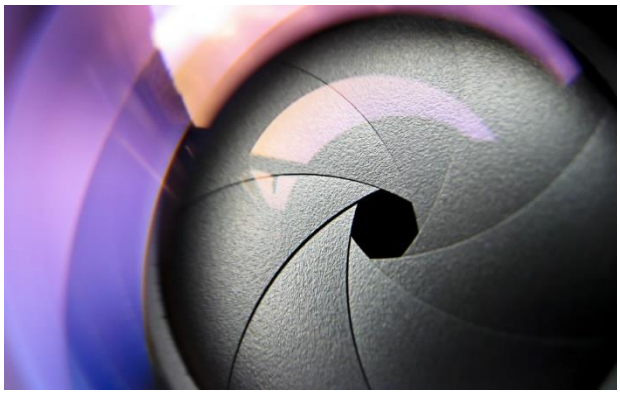


When you adjust the ISO, you vary the power of the amplifier which drives the sensor output. (A bit like turning up or down the volume on a radio.) The output of each pixel is increased to meet the desired level to produce a satisfactory image. The drawback of this is "noise" or "grain". This is basically unwanted and random interference, introduced with the higher ISO values. Noise often occurs in the low light areas of a digital image and is caused by low level background electronic emission within the digital sensor. (This also occurred in film, where the higher ASA (the predecessor to ISO) values gave a coarser or "grainer" result in an image, caused by the imperfections in the chemicals used to capture the light.)

However, the appearance of grain will depend upon the size of the final image as to how much it will show up. If the image is to be used, for example as a web-based image where the size is only a few centimetres, it is likely that only the coarsest grain will ever show. But if the image is to be used in a high-definition print of A3 or larger, or as a projected image from a video projector, noise will be more evident.

Aperture

Aperture refers to the opening in the lens that controls the amount of light that reaches the sensor. This is usually controlled by moveable vanes inside the lens which open and close when instructed by the user or by metering in full automatic mode.

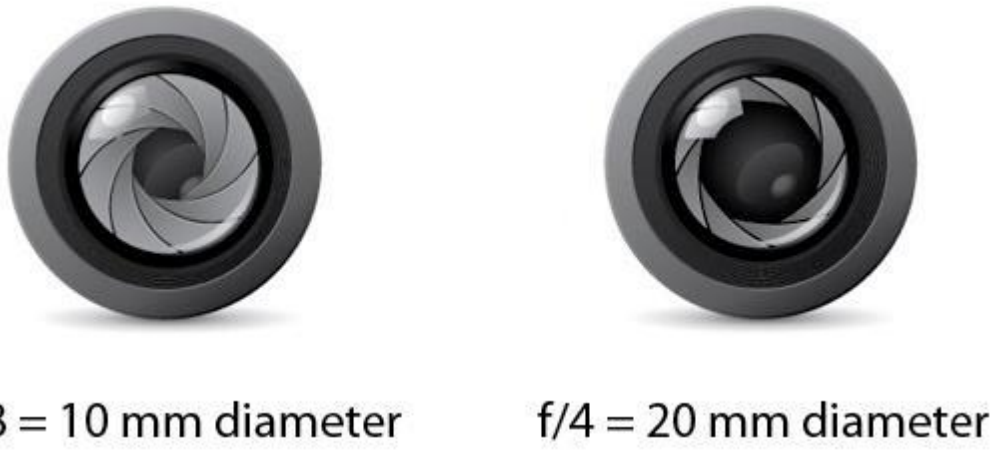


The vanes move together in an arc to allow less, or more light through the lens body to reach the sensor in the camera body. The more vanes used, the nearer the hole becomes circular, which produces a more circular aspect to out-of-focus points of light in images. The vanes are usually driven by a small motor to pre-set points known as stops.

Aperture stops, known as "f/stops" are similar to ISO values, increasing or decreasing by a factor of two: doubled or halved.

The "f" in f/stop represents the focal length of the lens, usually expressed in millimetres. If you are using an 80mm lens and have the aperture set to f/8, all this simply means is that the opening in the lens diaphragm is 80 mm (f) divided by eight, or 10 mm in diameter. That's all there is to it.

Setting the same lens to f/4 would increase the diameter of the diaphragm to 80 mm divided by 4 or an opening of 20 mm diameter. Sound simple? Well unfortunately, not quite.



The sting in the tail is that on the surface it looks like changing the aperture from f/8 to f/4, which doubles the diameter of the diaphragm, should let in twice as much light, but it actually lets in four times as much light. This is because it is the diameter that is doubled, but the area of the circular opening is actually quadrupled. The area of a circle is pi times the diameter squared and divided by four. Therefore, going from f/8 to f/4 actually represents two stops not one!

If you are beginning to panic - don't. You don't need to remember formulas you just need to understand the basic concept. For general purposes you only need to remember the progression of f/stops.

The smallest f/stop I have ever seen on a lens was f/128, so using that as a starting point the progression from smallest to largest aperture is f/128, f/90, f/64, f/45, f/32, f/22, f/16, f/11, f/8, f/5.6, f/4, f/2.8, f/2, f/1.4, f/1, f/0.7 up to a maximum of f/0.5, at which point the laws of physics prevents faster conventional lenses.

Stopping Down

F/STOPS	Size
f/128	Pin-point size
f/90	
f/64	
f/45	
f/32	Pin-head size
f/22	
f/16	
f/11	
f/8	Small pea
f/5.6	
f/4	
f/2.8	Small marble
f/2	
f/1.4	
f/1	Near fully-open
f/0.7	
f/0.5	

Opening Up

The term stopping down means to close the lens aperture. Opening up, means to open the lens aperture.

The smaller the aperture value, the larger the hole and vice-versa.

So, having seen how the aperture defines the "size of the hole" in the lens, we need to examine the other aspect caused by the aperture setting – Depth of Field (DoF). This determines how much of an image is in focus. This area is at right angles to the angle of view of the camera; that is to say, it runs left to right across the image. The actual depth depends upon the aperture setting and the distance of the subject from the camera. The greater the aperture, the smaller the depth of field. The greater the distance from the camera the larger the depth of field.

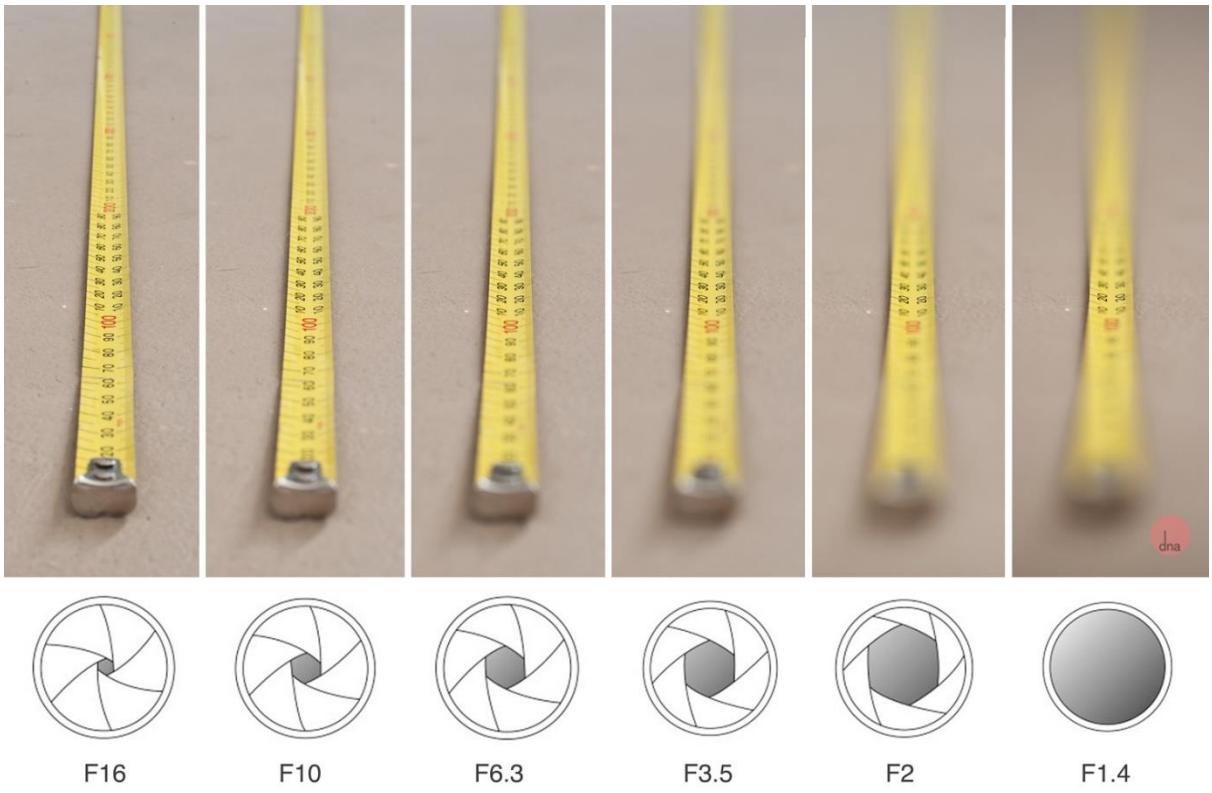
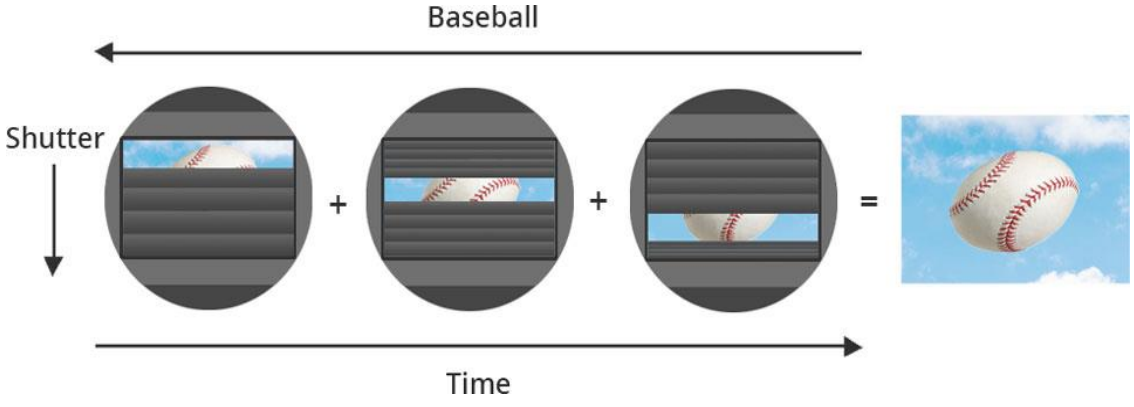


image courtesy of Pinterest

As can be seen here, the depth of field varies quite substantially between the various aperture settings.

Shutter Speed

The most commonly used shutter types found in modern cameras is the Focal Plane shutter. Comprised of a pair of metal blinds, the focal plane shutter is situated just in front of the sensor. One blind opens to expose the sensor to light and the other blind follows behind the first, closing the light path. In effect, the shutter paints the light through a slit between the two blinds in a horizontal direction across the sensor as the second blind closes closely behind the first blind. As there are two blinds working in unison, the focal plane shutter can be made to operate very quickly. At slow shutter speeds the entire sensor is simultaneously exposed to light. At faster shutter speeds, only a small portion of the sensor is exposed to light at any given time, as the slit between the blades moves rapidly across the sensor.



In Compact, phone and tablet cameras, there are no shutters (although the device makes a sound to mimic the sound of a shutter opening and closing, and in some cases, the sound of a mirror moving in a DSLR!) These cameras operate an electronic shutter that simply powers the digital sensor on for a selected amount of time. Because there is no mechanical function, electronic shutter speeds can be extremely fast.

By slowing the shutter speed, from 1/30th of a second to 1/15th of a second, for instance, we will double the amount of light passing through the shutter. This doubling of light is identical to the doubling of light accomplished by opening the aperture, albeit by a different mechanical function, and represents a +1 f/stop shift. Changing the shutter speed from 1/2000th of a second to 1/4000th of a second then halves the amount of light coming through the shutter and represents a -1 f/stop shift.

One of the major drawbacks of focal plane shutters has typically been the slow shutter speed required when using flash. Flash units often fire at speeds reaching 1/25,000 of a second and if the shutter is set to a high speed, where only a portion of the sensor is exposed, then only that portion of light will be exposed on the sensor and the rest of the image will remain black.

Older film based SLR cameras traditionally had a speed which synchronised with the flash at 1/60 second but modern DSLR's typically use 1/250 second or faster. This speed is known as the ‘sync speed’ and is the fastest speed the shutter can be set to when using flash. Of course, speeds slower than the sync speed can be used if desired.

Semi-Automatic Modes

In **Aperture Priority** (A or Av) and **Shutter Priority** (T or Av), the majority of control is yours, but the camera will retain aspects. As the name of each suggests, there is a priority given to the function that achieves the desired outcome. In Aperture Priority, the speed is set automatically, while in Shutter Priority, the aperture is set automatically, in the camera. Other functions such as metering (checking the amount of light hitting the sensor is not too bright or too dark) and focus remain automatic. Focus can be set to manual as well, but this adds to the complexity of decisions to be made for relative newcomers to photography. So, unless a subject is unlikely to move during the shot, it’s best to leave focus on automatic for now.

So, let us examine the two most popular modes: Aperture Priority ‘A’ - Aperture in Nikon and ‘Av’ - Aperture Value in Canon; and Shutter Priority ‘S’ - Speed in Nikon and ‘Tv’ – Time Value in Canon. (For the purpose of this article, I am not looking at the “P” mode.) If you have another make of camera, consult your manual to see what the manufacturer refers to as their equivalents.

Aperture Priority

Aperture Priority mode is semi-automatic. The settings that are down to you are the Aperture and the ISO. The considerations you make are based upon these two settings, the camera looks after the shutter speed for you. Aperture Priority allows you to consider not only the amount of light entering the camera, it also allows your decision on depth of field (DoF). Depending upon the subject, DoF may play a big part in composing the shot, to include all you want in focus and rendering unwanted items out of focus. By choosing a large aperture (f/2.8 to f/5.4), if the subject is fairly close to you, the background and foreground will be blurred – highlighting the subject with clarity.

In this image, I have purposely chosen a wide aperture (f/6.3) to keep only the eggs in focus. The foreground and background are purposely left "soft" to enhance the clarity of the eggs. A smaller aperture (f/8 or higher) would have brought the background and foreground more into focus, detracting from the final image.

The same idea is used here, but with the eggs arranged differently. As they are in a line diagonal to the camera, the area in focus (at f/4.0) runs parallel to the camera sensor, creating a narrow band of focus across the screen. This renders the nearer and further eggs out of focus leaving the centre egg the only thing in focus. The depth of field is narrower than the previous image as the aperture was larger.

However, Aperture Priority is not only used to put things out of focus. It also allows you to make the best of low-light situations, and make a decision on the speed at which the shot is taken.

When viewing an image in Aperture Priority mode, the two things you have direct control over are the aperture and the ISO setting. The camera monitors the settings you have made and adjusts the shutter speed to try to get a good exposure. By checking the speed in the viewfinder or on the rear screen in a compact camera, you are indirectly in control of the speed setting. If, for example, you are taking a shot in a church or similar building where flash is not welcome, you would first set the ISO setting to around ISO800. As you want the whole building in focus, the aperture would need to be fairly small, say around f/8 to f/11. By pressing the shutter button halfway down, the camera will examine the available light and set the shutter speed accordingly. If you check that speed before pressing the shutter release all the way down, you can see what the camera has set. (This will display as long as you hold the shutter half-pressed.) If this is below 125th of a second, it may cause camera shake as you take the shot.

If this is the case, you can then open the aperture slightly, and/or raise the ISO until the speed value has increased to a setting where camera shake is less of an issue. As can be seen in the image above taken at the Harry Potter Studio exhibition, low light was an issue. I wanted to retain the colour of the lights, so couldn't use flash. I also wanted the whole structure in focus, so a smaller aperture was needed for the model of the school. Using an aperture of f/7.0 and an ISO of 400, I was left with a shutter speed of 3/10^{ths} of a second, causing camera shake, as can be seen in the blurred image.

By increasing the ISO to 800, the speed the camera used was higher at a 40th of a second. A careful squeeze of the shutter release then allowed me to take the much sharper shot (right) where the camera shake is very much reduced.

For landscape photography, depth of field is greatly enlarged, as the subjects are mainly much further away from the camera. However, it may be that you want to photograph a loved one or a subject to be in focus, and leave the background out of focus. A wide aperture will help!

Shutter Priority

Shutter Priority mode is also a semi-automatic setting. The settings that are down to you are the Shutter Speed and the ISO. (If your camera doesn't have a physical mode dial, you sometimes can select shutter priority mode through the on-screen menus.)

It probably sounds obvious, but you use shutter-priority mode when you need to control shutter speed and don't care (much) about aperture. You determine the shutter speed you want, and the camera automatically adjusts the aperture to maintain the correct exposure.

When should you care most about shutter speed?

- When you're trying to stop action, you need to set the shutter speed faster than the subject you're photographing.
- If you want to make moving objects look blurry, you need to set the shutter speed slower than the subject.
- When you're using a telephoto lens without a tripod or if you have shaky hands, you have to set the shutter speed high enough that you won't introduce camera shake.

As you adjust the settings for the shutter speed, you'll probably find fast settings that begin at 1/2000 or 1/4000 and that may end at the slowest speeds of 1 or 2 seconds. The settings will nearly always be about half or double the previous setting, going from 1/30 to 1/60 to 1/125, and so on, although some cameras offer even more precise settings in between the standard shutter speed settings.

There will be times when shooting with shutter priority where you may want to use a relatively slow shutter speed. If you're going to shoot at a slow shutter speed, anything 1/60th or slower, you will likely need a tripod, a remote shutter, or a shutter release cable to shoot photos. At the slow shutter speeds, even the act of pressing a shutter button could jostle the camera enough to cause a blurry photo. It's also extremely difficult to hold a camera steady by hand when shooting at slow shutter speeds, meaning camera shake could cause a slightly blurry photo, unless you make use of a tripod.

At the other end of the scale, shutter priority can freeze or stop action. As action photography usually takes place in reasonably good light, corresponding apertures set by the camera, will allow sufficient depth of field to capture the subject fully. However, beware of setting the speed too high. The amount of light hitting the sensor may not be enough, resulting in under-exposure of the shot. The other side effect of too high a shutter speed is to totally freeze the action as in the shot above. Only the dust gives the impression of movement; the wheels are stationary.

By playing with speed settings, it is possible to get movement into the image to give the impression of speed, both in the moving parts and the background.

Putting It All Together

I was asked recently, what is my preferred method of taking pictures? My answer comes in two parts:

1. What is the eventual use of the resulting image?
2. What time do I have available to take the shot?

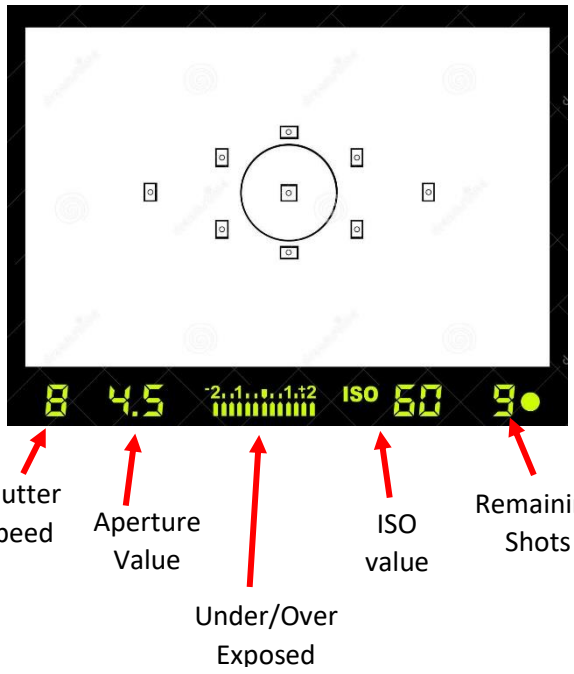
If I'm taking a "professional image" I may take a fully manual shot where I decide all of the settings, set up lighting to suit and generally "faff about" (as my wife would say) taking multiple shots at different settings and lighting set-ups. Time consuming, but I control the parameters and end up, hopefully, with a sharp, high definition shot.

In a more relaxed environment, such as on holiday, I almost always use Aperture Priority.

In an emergency situation, where there is no time to make any settings whatsoever, I'll dial up full auto and hope the unmissable has been caught!

So, for the vast majority of my time, the camera is set to **Aperture Priority**. Why?

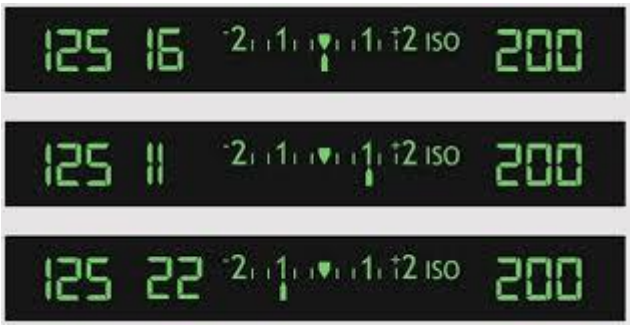
This semi-automatic mode allows me to set two of the three parameters: Aperture and ISO. The third, Shutter Speed is set by the camera according to the settings I make. First, I will judge the general light available and set the ISO accordingly. Then I will set the aperture for both light and depth of field. I then aim the camera, half-press the shutter and look in the viewfinder to see what speed the camera has decided to fire the shutter for me. At this point, I make the decision whether to take the shot, or to make adjustments to either the ISO (to increase the sensitivity of the sensor to increase the shutter speed) or aperture to increase the amount of light hitting the sensor (to save raising the ISO).



For DSLRs, all of this is viewable in the viewfinder, similar to the one shown on the left. (Other cameras will display the values on the rear-view screen.) As you vary the aperture or the ISO, watch the speed value and see if it is suitable for the shot. (Here, it is way below hand-held speed at 1/8th of a second.) If this were the values presented to me, I would raise the ISO to around 400, but keep the aperture the same for my depth-of-field requirement.

One item not spoken about before is the light meter that is shown on most cameras, either in the viewfinder or on the rear-view screen.

This is a representation of whether the image is over or under-exposed, in a value of f/stops, of one, two, or three stops (and part stops.) If the highlight is to the left, the shot is under-exposed. If it is to the right the shot is over-exposed.



It can be seen here that the correct exposure is 125th of a second at f/16, ISO 200. (This suggests a bright sunny day, taking a landscape shot – a high f/ value, low ISO, fairly fast shutter speed.) If the aperture value is lowered to f/11, the shot becomes over-exposed (by one stop). If the aperture value is raised to f/22, the shot is under-exposed. The shutter speed and ISO remain the same, the aperture is the setting that is changed.

It is a matter of preference and the image you wish to capture and how much time you have to make the shot. As I know Aperture Priority well, it is my preferred choice. Many of the shots I take require me to concentrate more on what is in focus and what is not. In my studio, everything is shot on manual, where I use light meters to check the light available, and the best speed to use, at the ISO of my choosing, by varying the intensity and position of the light I use.

If your hobby is action photography, try Shutter Priority, and vary the speed to capture movement. If you love landscapes and wildlife photography, Aperture Priority may be best to bring foreground images into focus, and blur the background. Portraiture demands manual settings, but that is a whole different subject!

Trial and error is the best way to find what suits you best.

It's digital – it's "free" to experiment!

Bob Holder