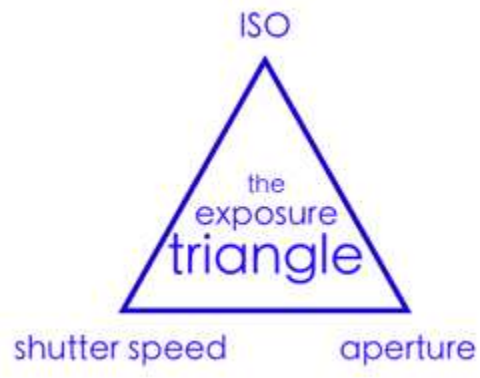


Learning about Exposure - The Exposure Triangle

Bryan Peterson has written a book titled **Understanding Exposure** which is worth a read if you're wanting to venture out of the Auto mode on your digital camera and experiment with it's manual settings.

In it Bryan illustrates the three main elements that need to be considered when playing around with exposure by calling them 'the exposure triangle'.

Each of the three aspects of the triangle relate to light and how it enters and interacts with the camera.

The three elements are:

1. **ISO** - the measure of a digital camera sensor's sensitivity to light
2. **Aperture** - the size of the opening in the lens when a picture is taken
3. **Shutter Speed** - the amount of time that the shutter is open

Is is at the intersection of these three elements that an image's exposure is worked out.

Most importantly - a change in one of the elements will impact the others. This means that you can never really isolate just one of the elements alone but always need to have the others in the back of your mind.

Some metaphors for understanding the digital photography exposure triangle:

Many people describe the relationship between ISO, Aperture and Shutter Speed using different metaphors to help us get our heads around it. Let me share a couple. A quick word of warning first though - like most metaphors - these are far from perfect and are just for illustrative purposes:

The Window

Imagine your camera is like a window with shutters that open and close.

Aperture is the size of the window. If it's bigger more light gets through and the room is brighter.

Shutter Speed is the amount of time that the shutters of the window are open. The longer you leave them open the more that comes in.

Now imagine that you're inside the room and are wearing sunglasses (hopefully this isn't too much of a stretch). Your eyes become desensitized to the light that comes in (it's like a low ISO).

There are a number of ways of increasing the amount of light in the room (or at least how much it seems that there is. You could increase the time that the shutters are open (decrease shutter speed), you could increase the size of the window (increase aperture) or you could take off your sunglasses (make the ISO larger).

Ok - it's not the perfect illustration - but you get the idea.

Sunbaking

Another way that a friend recently shared with me is to think about digital camera exposure as being like getting a sun tan.

Now getting a suntan is something I always wanted growing up - but unfortunately being very fair skinned it was something that I never really achieved. All I did was get burnt when I went out into the sun. In a sense your skin type is like an ISO rating. Some people are more sensitive to the sun than others.

Shutter speed in this metaphor is like the length of time you spend out in the sun. The longer you spend in the sun the increased chances of you getting a tan (of course spending too long in the sun can mean being over exposed).

Aperture is like sunscreen which you apply to your skin. Sunscreen blocks the sun at different rates depending upon it's strength. Apply a high strength sunscreen and you decrease the amount of sunlight that gets through - and as a result even a person with highly sensitive skin can spend more time in the sun (ie decrease the Aperture and you can slow down shutter speed and/or decrease ISO).

As I've said - neither metaphor is perfect but both illustrate the interconnectedness of shutter speed, aperture and ISO on your digital camera.

NB: A third metaphor that I've heard used is the Garden Hose (the width of the hose is aperture, the length that the hose is left on is shutter speed and the pressure of the water (the speed it gets through) is ISO.

Bringing It All Together

Mastering the art of exposure is something that takes a lot of practice. In many ways it's a juggling act and even the most experienced photographers experiment and tweak their settings as they go. Keep in mind that changing each element not only impacts the exposure of the image but each one also has an impact upon other aspects of it (ie changing aperture changes depth of field, changing ISO changes the graininess of a shot and changing shutter speed impacts how motion is captured).

The great thing about digital cameras is that they are the ideal testing bed for learning about exposure. You can take as many shots as you like at no cost and they not only allow you to shoot in Auto mode and Manual mode - but also generally have semi-automatic modes like aperture priority and shutter priority modes which allow you to make decisions about one or two elements of the triangle and let the camera handle the other elements.

A lot more can be said about each of the three elements in the exposure triangle. I've already **written a post on ISO** and in the coming week or so will tackle both shutter speed and aperture in greater depth.

ISO Settings in Digital Photography

Grant (a reader of DPS) asks - *'I'm confused about **ISO**. What is the best setting to choose? Should I always choose the lowest one?'*

Thanks for the question Grant. Before I attempt to answer it let me give a quick **definition of ISO**:

What is ISO?

In traditional (film) photography ISO (or ASA) was the indication of how sensitive a film was to light. It was measured in numbers (you've probably seen them on films - 100, 200, 400, 800 etc). The lower the number the lower the sensitivity of the film and the finer the grain in the shots you're taking.

In Digital Photography ISO measures the sensitivity of the image sensor. The same principles apply as in film photography - the lower the number the less sensitive your camera is to light and the finer the grain. Higher ISO settings are generally used in darker situations to get faster shutter speeds (for example an indoor sports event when you want to freeze the action in lower light) - however the cost is noisier shots. I'll illustrate this below with two elargements of shots that I just took - the one on the left is taken at 100 ISO and the one of the right at 3200 ISO (click to enlarge to see the full effect).

(you can see larger sized images of both shots **here for the 100 ISO** and **here for the 3200 ISO**)

100 ISO is generally accepted as 'normal' and will give you lovely crisp shots (little noise/grain).

Most people tend to keep their digital cameras in 'Auto Mode' where the camera selects the appropriate ISO setting depending upon the conditions you're shooting in (it will try to keep it as low as possible) but most cameras also give you the opportunity to select your own ISO also.

When you do override your camera and choose a specific ISO you'll notice that it impacts the aperture and shutter speed needed for a well exposed shot. For example - if you bumped your ISO up from 100 to 400 you'll notice that you can shoot at higher shutter speeds and/or smaller apertures.

When choosing the ISO setting I generally ask myself the following four questions:

1. **Light** - Is the subject well lit?
2. **Grain** - Do I want a grainy shot or one without noise?
3. **Tripod** - Am I use a tripod?

4. **Moving** Subject - Is my subject moving or stationary?

If there is plenty of light, I want little grain, I'm using a tripod and my subject is stationary I will generally use a pretty low ISO rating.

However if it's dark, I purposely want grain, I don't have a tripod and/or my subject is moving I might consider increasing the ISO as it will enable me to shoot with a faster shutter speed and still expose the shot well.

Of course the trade off of this increase in ISO will be noisier shots.

Situations where you might need to push ISO to higher settings include:

- **Indoor Sports Events** - where your subject is moving fast yet you may have limited light available.
- **Concerts** - also low in light and often 'no-flash' zones
- **Art Galleries, Churches** etc- many galleries have rules against using a flash and of course being indoors are not well lit.
- **Birthday Parties** - blowing out the candles in a dark room can give you a nice moody shot which would be ruined by a bright flash. Increasing the ISO can help capture the scene.

ISO is an important aspect of digital photography to have an understanding of if you want to gain more control of your digital camera. Experiment with different settings and how they impact your images today.

What is Aperture?

Put most simply - Aperture is 'the size of the opening in the lens when a picture is taken.'

When you hit the shutter release button of your camera a hole opens up that allows your cameras image sensor to catch a glimpse of the scene you're wanting to capture. The aperture that you set impacts the size of that hole. The larger the hole the more light that gets in - the smaller the hole the less light.

Aperture is measured in 'f-stops'. You'll often see them referred to here at Digital Photography School as f/number - for example f/2.8, f/4, f/5.6,f/8,f/22 etc. Moving from one f-stop to the next doubles or halves the size of the amount of opening in your lens (and the amount of light getting through). Keep in mind that a change in shutter speed from one stop to the next doubles or halves the amount of light that

gets in also - this means if you increase one and decrease the other you let the same amount of light in - very handy to keep in mind).

One thing that causes a lot of new photographers confusion is that large apertures (where lots of light gets through) are given f/stop smaller numbers and smaller apertures (where less light gets through) have larger f-stop numbers. So f/2.8 is in fact a much larger aperture than f/22. It seems the wrong way around when you first hear it but you'll get the hang of it.

Depth of Field and Aperture

There are a number of results of changing the aperture of your shots that you'll want to keep in mind as you consider your setting but the most noticeable one will be the depth of field that your shot will have.

Depth of Field (DOF) is that amount of your shot that will be in focus. **Large depth of field** means that most of your image will be in focus whether it's close to your camera or far away (like the picture to the left where both the foreground and background are largely in focus - taken with an aperture of f/22).

Small (or shallow) depth of field means that only part of the image will be in focus and the rest will be fuzzy (like in the flower at the top of this post (click to enlarge). You'll see in it that the tip of the yellow stems are in focus but even though they are only 1cm or so behind them that the petals are out of focus. This is a very shallow depth of field and was taken with an aperture of f/4.5).

Aperture has a big impact upon depth of field. Large aperture (remember it's a smaller number) will decrease depth of field while small aperture (larger numbers) will give you larger depth of field.


It can be a little confusing at first but the way I remember it is that small numbers mean small DOF and large numbers mean large DOF.

Let me illustrate this with two pictures I took earlier this week in my garden of two flowers.

The first picture below (click them to enlarge) on the left was taken with an aperture of f/22 and the second one was taken with an aperture of f/2.8. The difference is quite obvious. The f/22 picture has both the flower and the bud in focus and you're able to make out the shape of the fence and leaves in the background.

The f/2.8 shot (2nd one) has the left flower in focus (or parts of it) but the depth of field is very shallow and the background is thrown out of focus and the bud to the right of the flower is also less in focus due to it being slightly further away from the camera when the shot was taken.

The best way to get your head around aperture is to get your camera out and do some experimenting. Go outside and find a spot where you've got items close to you as well as far away and take a series of shots with different aperture settings from the smallest setting to the largest. You'll quickly see the impact that it can have and the usefulness of being able to control aperture.

Some styles of photography require large depths of field (and small Apertures)

For example in most landscape photography you'll see small aperture settings (large numbers) selected by photographers. This ensures that from the foreground to the horizon is relatively in focus.

On the other hand in portrait photography it can be very handy to have your subject perfectly in focus but to have a nice blurry background in order to ensure

that your subject is the main focal point and that other elements in the shot are not distracting. In this case you'd choose a large aperture (small number) to ensure a shallow depth of field.

Macro photographers tend to be big users of large apertures to ensure that the element of their subject that they are focusing in on totally captures the attention of the viewer of their images while the rest of the image is completely thrown out of focus.

*The following guest tip on **The Beauty Of Large Aperture In Digital Photography** was submitted by Amy Renfrey - author of the **Digital Photography Success ebook**.*

In digital photography there is one thing that, for crisp images, you simply must know about. And that's the proper use of your aperture. When you use your aperture the right way in your digital photography you can really influence a lot of creative factors. What I am about to tell you will help your digital photography a lot, because you'll be discovering a professional digital photography technique.

In digital photography there are measurements of light control called ISO, Shutter speed, E/V and Aperture. The most important thing to start with in digital photography is to get your head around aperture and how it controls many creative aspects of digital photography.

As you know digital photography images depend on just the right amount of light falling on to the sensor. An aperture, measured in F stops, is a crucial aspect to how much light the camera gets.

A large aperture allows a lot more light to fall onto the sensor, and when this happens you have the freedom of using a faster shutter speed. This is especially handy in situations of low light and fast movement, such as indoor sports or a water fall at the end of the day. That's why larger apertures and fast action shots indoors need to go hand in hand. By widening your aperture you have a better chance of the movement being frozen in time and the camera won't have time to think about camera shake. If done right, you'll find good sharp images of freeze frame shots without any blur at all.

In your digital photography you should also know that also a large aperture can give you a crisp depth of field. It gives you the opportunity to have your background out of focus giving you clearer focus for the subject close up. (You should always use macro lenses for very short depth of field because you get more clarity and sharpness. You can get in closer too, without the subject blurring as it would have without the macro lens.) Portrait photography works well this way.

On the other hand, a small aperture in your digital photography gives you the opportunity to get a slower shutter speed because once light is reduced onto the sensor, the shutter speed will respond.

A smaller aperture in digital photography increases the depth of field because it influences the focal length. When you have an increased depth of field you will notice much sharper images in long distance shots such as landscapes and cityscapes. So if you are having any challenges with lighting and movement then try this digital photography tip!

When taking a photograph, there are really only three controls that matter on a camera: focus, shutter speed and aperture. Focus is reasonably obvious; you can quickly spot when a picture is out of focus. Likewise shutter speed is easy to understand since it is measured in fractions of a second. However aperture is a mystery to most people, because it is usually explained using technical jargon and its effects are not immediately obvious.

In this tutorial I'll attempt to explain how changing the aperture affects how your photograph will look, and how you can use those effects creatively to take better pictures.

The aperture is literally that – a hole through which light passes after it enters the lens. The size of this hole can be altered, allowing a greater or smaller amount of light to pass through.

Wide aperture: a Pentax f1.7 50mm lens set at f2.8

Narrow aperture: a Pentax f1.7 50mm lens set at f16

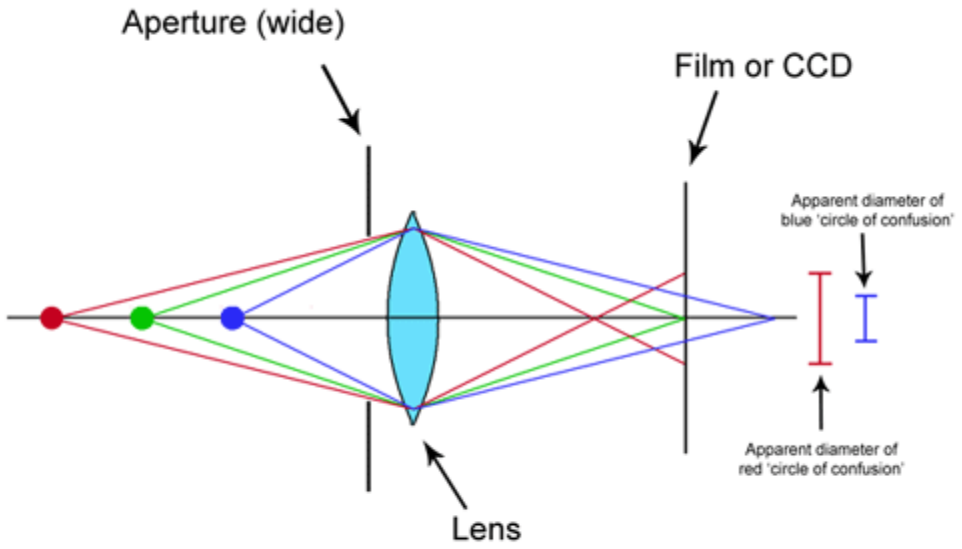
Aperture is used in conjunction with shutter speed to control exposure, as explained in **last month's tutorial**. However it is also the primary means of controlling something called depth of field.

If you take a photo of someone at a range of about three metres with a normal automatic compact camera, in good light with the lens zoomed in about half way, you'll usually find that objects about 1.5m in front of the subject, and for about four or five metres behind the subject, also appear sharp. This distance, from the closest point of acceptable sharpness to the most distant, is the depth of field. By altering the size of the aperture, we can control the size of this depth of field, either reducing it so that only our subject is in focus, or expanding it so that an entire landscape can appear sharp.

If you have an older camera lying about, take a look at the lens. It should have a movable ring for controlling the aperture setting, labelled with numbers from about F2 to F22. It will also have a ring for adjusting the focus distance, usually calibrated in feet and metres. Alongside that scale, you'll usually find lines marked with the same numbers as the aperture ring, but in pairs either side of the distance indicator mark, with the larger F-numbers toward the outside. This is done to help estimate the depth of field at a particular distance and aperture setting; on the distance scale everything between the two lines for a given aperture setting will be acceptably sharp.

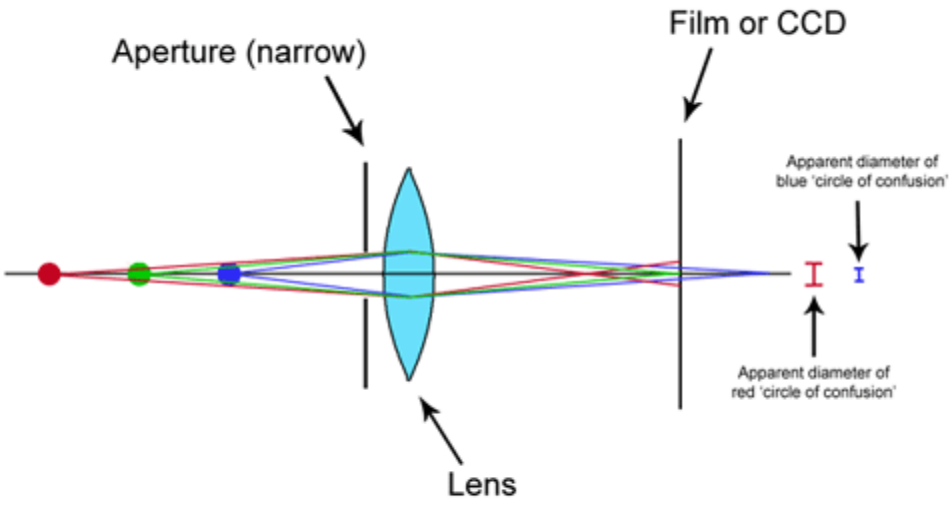
Unfortunately this feature is missing from most modern auto-focus, auto-aperture lenses.

Explaining exactly why changing the size of the aperture alters the depth of field is going to get a little bit technical, but I've always found that it's a lot easier to understand and remember something if you know how it works. Don't worry, I'm not going to go into the maths here, but I am going to inflict a couple of diagrams on you.



This is a highly simplified diagram of the arrangement of lens, aperture and sensor inside your camera. In this first diagram, our subjects are the three spots, red, green and blue, which are at different distances from the camera. The camera lens is focused on the green spot, which means that light from the green spot passes through the aperture and the lens and is focused on the CCD. Light from the red and blue spots also passes through the aperture and lens, but light from the red spot focuses a short distance in front of the CCD, while light from the blue spot would focus a short distance behind it. The light from these other spots still hits the CCD, but due to light scattering it is unfocused and spread over a wide area.

What this means is that the red and blue spots will appear as large blurred spots on the final image, while the green spot will be sharp and in focus. The size of the blurred area of the red and blue spots is called the circle of confusion.



In this diagram we have the same setup, and the coloured spots are the same distance from the lens, but this time the aperture has been reduced to just a small hole. Again the lens is focused on the green spot, and the red and blue spots are out of focus. However the narrow aperture restricts the light scattering and the relative angles of the light paths, and as a result the 'circles of confusion' are much smaller. This makes the red and blue spots in the final image appear much sharper. They are still out of focus, but the effect is not so noticeable. To make circles of confusion as large as in the first image, the red and blue spots would have to be much further away from the green one.

The easiest way to demonstrate the effect of changing depth of field is with some example shots. For some reason I've never been able to explain, every photography textbook I've ever read, and even my university lecturer, used photos of a row of chess pieces to illustrate this, so just to be different I'm going to use my favourite model cars.

This shot was taken using a medium telephoto lens set on a focal length of 43mm, and the front of the Aston Martin DB5 (the silver one in the middle), the point on which the camera is focused, is approximately one metre from the camera. The aperture is set to f4, which is the maximum for this lens, producing the smallest possible depth of field. As you can see only the right front wing of the Aston Martin and the back of the Lotus Esprit (the red one at the front) are in focus. The depth of field for this shot is about 10cm.

By reducing the aperture by two stops to f8, the depth of field is slightly increased, to about 20cm. Now the lettering on the Lotus' tyres is readable, although the classic 1937 Jaguar SS100 (the green one) is still very blurred.

Reducing the aperture to its smallest setting of f22 maximises the depth of field. In this shot everything looks sharp. You can even read the number plate on the Jaguar.

There are several situations where controlling depth of field is important. The most common is portrait photography. As I mentioned at the start, portraits shot on an automatic camera using a medium aperture usually have a lot of sharp foreground and background detail, which can distract attention away from the main subject.

As you can see in this shot, which was taken using an aperture of f22, the model is in focus, but so is the background, which unfortunately makes it look like she has a tree growing out of the top of head.

By increasing the aperture to f5.6, we can make sure that only the subject is in focus. A blurred background is much less distracting, and the distance between the subject and the background is far more apparent.

Another situation in which depth of field is an important issue is landscape photography. Here it is often important to get the maximum depth of field possible, so it is usual to use the smallest possible aperture. This shot was taken using and aperture of f22, to ensure that both the foreground and distant background are in focus.

Focal length and depth of field

The focal length of your lens, in other words how much you zoom in on your subject, also has a large effect on depth of field. Generally short focal lengths (wide-angle settings) have much greater depth of field than longer focal lengths. This is one reason why, when taking a portrait shot, it’s a good idea to step back a bit and zoom in rather than using a wide angle lens up close. I’ll cover this in more depth in my next tutorial.

Hyperfocal distance

This is a specialised technique of landscape photography which involves manually focusing the camera to the closest point where the depth of field makes everything in the shot sharp. Again, I'll cover this topic in more detail in a future tutorial.

Introduction to Shutter Speed in Digital Photography

Previously I've introduced the concept of the **Exposure Triangle** as a way of thinking about getting out of Auto Mode and exploring the idea of manually adjusting the exposure of your shots.

The three main areas that you can adjust are ISO, Aperture and **Shutter speed**. I've **previously looked at making adjustments to ISO** and now want to turn our attention to shutter speed.

What is Shutter Speed?

As I've written elsewhere, defined most basically - **shutter speed is 'the amount of time that the shutter is open'**.

In film photography it was the length of time that the film was exposed to the scene you're photographing and similarly in digital photography shutter speed is the length of time that your image sensor 'sees' the scene you're attempting to capture.

Let me attempt to break down the topic into some bite sized pieces that should help digital camera owners trying to get their head around shutter speed:

- **Shutter speed is measured in seconds** - or in most cases fractions of seconds. The bigger the denominator the faster the speed (ie 1/1000 is much faster than 1/30).
- **In most cases you'll probably be using shutter speeds of 1/60th of a second or faster**. This is because anything slower than this is very difficult to use without getting camera shake. Camera shake is when your camera is moving while the shutter is open and results in blur in your photos.
- **If you're using a slow shutter speed (anything slower than 1/60) you will need to either use a tripod** or some some type of image stabilization (more and more cameras are coming with this built in).
- **Shutter speeds available to you on your camera will usually double (approximately) with each setting.** As a result you'll usually have the options for the following shutter speeds - 1/500, 1/250, 1/125, 1/60, 1/30, 1/15, 1/8 etc. This 'doubling' is handy to keep in mind as aperture settings also double the amount of light that is let in - as a result increasing shutter speed by one stop and decreasing aperture by one stop should give you similar exposure levels (but we'll talk more about this in a future post).
- **Some cameras also give you the option for very slow shutter speeds** that are not fractions of seconds but are measured in seconds (for example 1 second, 10 seconds, 30 seconds etc). These are used in very low light situations, when you're going after special effects and/or when you're trying to capture a lot of movement in a shot). Some cameras also give you the option to shoot in 'B' (or 'Bulb') mode. Bulb mode lets you keep the shutter open for as long as you hold it down.

- **When considering what shutter speed to use in an image you should always ask yourself whether anything in your scene is moving** and how you'd like to capture that movement. If there is movement in your scene you have the choice of either freezing the movement (so it looks still) or letting the moving object intentionally blur (giving it a sense of movement).
- **To freeze movement in an image** (like in the surfing shot above) you'll want to choose a faster shutter speed and to let the movement blur you'll want to choose a slower shutter speed. The actual speeds you should choose will vary depending upon the speed of the subject in your shot and how much you want it to be blurred.

- **Motion is not always bad** - I spoke to one digital camera owner last week who told me that he always used fast shutter speeds and couldn't understand why anyone would want motion in their images. There are times when motion is good. For example when you're taking a photo of a waterfall and want to show how fast the water is flowing, or when you're taking a shot of a racing car and want to give it a feeling of speed, or when you're taking a shot of a star scape and want to show how the stars move over a longer period of time etc. In all of these instances choosing a longer shutter speed will be the way to go. However in all of these cases you need to use a tripod or you'll run the risk of ruining the shots by adding camera movement (a different type of blur than motion blur).
- **Focal Length and Shutter Speed** - another thing to consider when choosing shutter speed is the focal length of the lens you're using. Longer focal lengths will accentuate the amount of camera shake you have and so you'll need to choose a faster shutter speed (unless you have image stabilization in your lens or camera). The 'rule' of thumb to use with focal length in non image stabilized situations) is to choose a shutter speed with a denominator that is larger than the focal length of the lens. For example if you have a lens that is 50mm 1/60th is probably ok but if you have a 200mm lens you'll probably want to shoot at around 1/250.

Bringing it Together - Remember that thinking about Shutter Speed in isolation from the other two elements of the Exposure Triangle (aperture and ISO) is not really a good idea. As you change shutter speed you'll need to change one or both of the other elements to compensate for it.

For example if you speed up your shutter speed one stop (for example from 1/125th to 1/250th) you're effectively letting half as much light into your camera. To compensate for this you'll probably need to increase your aperture one stop (for example from f16 to f11). The other alternative would be to choose a faster ISO rating (you might want to move from ISO 100 to ISO 400 for example).