Most of us have heard, and probably used, the term **f-number**. Most of us have also probably used the term interchangeably with “f-stop” or “aperture”. What are all these things, really? Yes, they have to do with the size of the hole allowing light to pass through the lens, and they affect depth of field and light intensity. But I’m talking about what these things really *are*.

Some definitions. An **aperture** is simply a hole which allows light to pass through it. A **diaphragm** is the mechanism inside your lens that forms an aperture, and most modern lenses have an *iris diaphragm* made up of several interlocking blades. An **f-stop** is a discrete step in the f-number, and it refers to the physical stops in the diaphragm adjustment. So how are all these things different from an f-number?

An f-number is a measure of lens 'speed' and it is defined by the focal length of the lens divided by the diameter of the aperture — f/# = f/D where f = focal length and D = aperture diameter. So if the focal length of the lens is equal to the diameter of the aperture, you’d have an f/1. If the focal length of the lens is 8 times longer than the diameter of the aperture, you’d have an f/8.

F-Number = f/D = (Focal Length)/(Aperture Diameter)

Here’s an example with a common (but quite expensive) fixed focal length lens (zooms are a little more complicated so I’ll hit that in a moment). Let's say we have a 50mm f/1.4 lens. The f/1.4 means that it has a *minimum* f-number (or maximum aperture) of 1.4 — so that’s as *big* as it gets. The maximum f-number (or minimum aperture) on this lens is f/16, so that's as *small* as it gets. So using the formula for f-number: at a 50mm focal length and an f-number of 1.4, the equation states 1.4(f/#) = 50mm(f)/(D). That gives us 50mm/1.4 = 35.7mm. That’s physically how big the aperture is at its maximum. If we had a f/1.2 lens, the max aperture would be 41.7mm. Now to the other end of the scale, the aperture on this lens has a minimum diameter of f/16, so 50mm/16 = 3.1mm. Similarly, a 105mm f/2.8 lens has a maximum f-number of f/2.8, an aperture diameter of 37.5mm — which is about the same size as the 50mm lens at f/1.4, which is two stops up from f/2.8.

You'll have noticed that long lenses, whether zoom or prime, always have a higher f-Number. Take a 300mm lens, for example, if it were f/2 then the aperture would need to be 150mm diameter... that's about 6 inches so it's not a physical possibility when you consider the space at the front of the camera for the lens to be attached to. The best you'll get in a 'simple lens', is about f/3.5 or f/4, because you're still limited to the physical space for the lens to fit in its 'mount', which is going to be around the 35mm point..... until, of course, we get to the true professional cameras of 'Medium Format' and bigger, which can have a huge space at the front for the lens mount. However, if money's no object, there are expensive and clever lenses that reflect the light inside themselves or do other tricks, like concentrating the light through to a smaller aperture, e.g. the Canon 600mm f/4 lens – that would need an aperture of 150mm, right? Well no, it's suitable for most Canon DSLRs – but it costs around $10,000. Nikon has a 400mm f2.8 that applies similar tricks – costs around $10,000 too.

for a 50mm lens…		
F-NUMBER	**APERTURE DIAMETER**	**APERTURE AREA**
1/#	***mm***	*sq mm*
1.4	35.7	1002
2	25.0	491
2.8	17.9	250
4	12.5	123
5.6	8.9	63
8	6.3	31
11	4.5	16
16	3.1	8

On the 50mm lens, including the minimum and maximum f-numbers, there are a total of 8 full f-stops: f/1.4, 2, 2.8, 4, 5.6, 8, 11, and 16, with half-stops between everything but 1.4 and 2 (things like f/1.7, f/6.7, and f/9.5 are half stops — f/1.8, f/3.5, and f/6.3 are third stops found in most modern lenses). **Each full stop lets half as much light in as the last full stop**. This is because the *area* of the aperture is reduced by half with each stop. The values in the table represent the f-numbers, aperture diameters, and aperture areas for this lens. Note the reduction of area as the f-numbers increase. Each full stop down lets half as much light into the camera, and you can see that the area of the aperture for each stop is also cut in half. This is where a lot of people end up confusing themselves over f-numbers. **Higher f-numbers mean smaller apertures** — just remember that. To help explain the numbers in the table a little better, the image below shows the 50mm lens at each full stop from f/1.4 to f/16 from left to right.

Zoom lenses are a bit more complicated, and they generally fall into two groups: constant f-number and variable f-number. **Variable f-number zooms** are most common because they are simpler and cheaper. You can spot these lenses by their markings — f/3.5-6.3 means that the lens has a maximum f-number of f/3.5 at the shorter focal length and f/6.3 at the longer focal length. This doesn't mean that the aperture changes as you zoom; it actually means that it doesn't change. Remember that f-number is the quotient of focal length and aperture diameter, so as you zoom to a higher focal length (and keep the aperture constant) you allow less light into the camera and the f-number changes. On the other hand, the really speedy, but expensive, zoom lenses can maintain a **constant f-number** at all focal lengths. To achieve this, they must increase the effective aperture diameter as the focal length increases to keep the same f-number ratio.

F-numbers in zoom lenses aren't quite as simple as I've made them out to be. That's basically how they work, but truthfully, I don't know exactly how they work. If you run the numbers on a zoom lens, it turns out that you don't get a constant aperture diameter as the focal length increases and the f-number changes. Physically, I'm pretty sure the aperture diameter stays the same. But when you zoom a lens, you shift the location of lens elements, the diaphragm, focal planes, inflection points, etc., and some of these things are factors for the ***effective aperture diameter***. I'm not an optics expert, so I'll leave it at that.

Basically, **the major take-away** from all this techno-babble should be that the **f-number is a measure of lens speed** — regardless of the camera, regardless of the lens, and regardless of the conditions. If you and a friend are out shooting, you should be able to get the same exposure of a particular subject if you shoot using the same f-number, shutter speed, and ISO value. It takes the focal length and aperture diameter into account in order to give a value of how much light will be allowed into the camera.