Welcome all Ricky Tims Challenge participants!

I am writing this to clarify the "1/3-2/3" depth of field technique that Ricky mentioned in his video. This is an approximation (but a useful approximation) of what actually happens with depth of field. In college, I spent two years studying Professional Photography, and one summer studying Photographic Science. During that summer I did a project that investigated depth of field. I am also drawing upon the excellent Wikipedia article on depth of field: https://en.wikipedia.org/wiki/Depth_of_field.

In the olden days, camera lenses had depth of field scales engraved on them.

This image shows an older lens focused at about 30 feet. The depth of field scale shows the range of distances that would be in acceptable focus for various aperture settings.

- If the lens were set to f/4, the range of distances in acceptable focus would be about 25 feet to roughly 40 feet. The total depth of field: 15 feet; DOF closer to the camera: 5 feet; DOF farther from the camera: 10 feet. In this example, 1/3 of the area of sharp focus is closer to the camera, and 2/3 of it is farther from the camera.
- If the lens were set to f/16, the range of distances in acceptable focus would be about 17 feet to roughly 80 feet. Total DOF: about 63 feet; DOF closer to the camera: 13 feet; DOF farther from the camera: 50 feet. Here only 1/5 of the range of sharp focus is closer to the camera and 4/5 of it is farther away.
- If the lens were set to f/22, the range of distances in acceptable focus would be about 14 feet to infinity! The total depth of field is infinite so we cannot calculate a ratio of the closer and farther distances.

Here is a different lens, focused closer.

This lens is focused at 5 feet. The depth of field scale shows:

- If the lens were set to f/11, the range of distances in acceptable focus would be about 4 feet to about 7 feet (3 feet total, 1/3 of which is closer to the camera, 2/3 farther from the camera).
- If the lens were set to f/22, the range of distances in acceptable focus would be about 3.5 feet to about 9 feet (5.5 feet total, ¼ of which is closer to the camera, ¾ farther).

What can we learn from these examples?

- The second lens, focused much closer, had less depth of field.
- The first lens, focused farther away, had much more depth of field.
- Furthermore, the first lens—if set to f/22 or more—had depth of field that extended to infinity.

Conclusions:

1. Depth of field depends on the aperture: The larger the aperture (smaller the f-number), the smaller the depth of field; the smaller the aperture (larger the f-number), the larger the depth of field.
2. Depth of field depends on the subject distance: The closer you focus, the smaller the depth of field; the farther away you focus, the larger the depth of field.
3. Of the range of distances that are in sharp focus, the amount that is closer to the camera and the amount that is farther from the camera also depends on the subject distance. The closer you focus, the more nearly equal these will be; the farther away you focus, the larger the amount farther from the camera will be as compared to the amount nearer.

In addition, for any particular lens and f-stop combination, there is a magical value called the *hyperfocal distance*. If you focus at this distance, everything from ½ this distance to infinity will be in (acceptably) sharp focus!

All of my old film camera lenses had depth of field scales on them, and it was easy to set the lens at the hyperfocal distance: just put the infinity symbol over the mark on the scale for the f-stop you were using. But none of my current Nikon lenses have this scale on them. (In fairness, I must point out that it is difficult to have such a scale on zoom lenses, though I have seen it done!)

So how are you to know what the hyperfocal distance is for a particular lens and f-stop combination? You can calculate it using the formula shown in the Wikipedia article mentioned earlier:

$$H = \frac{f^2}{Nc} + f$$

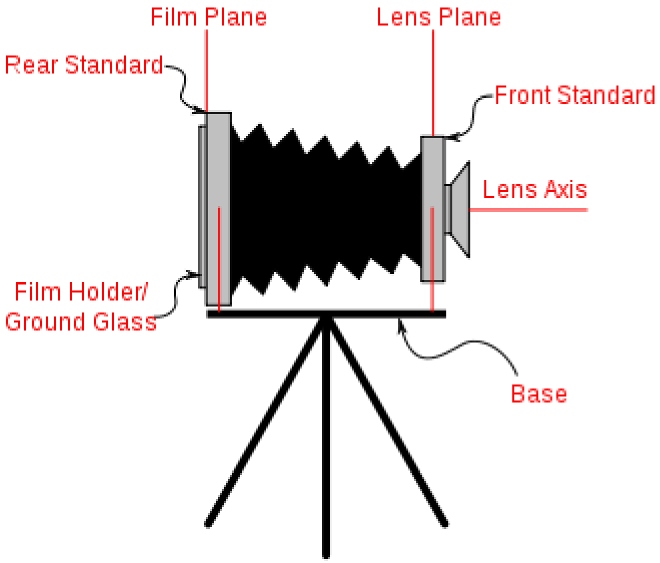
H is the hyperfocal distance, f is the focal length of the lens, N is the f-number, and c is the circle of confusion (see http://www.kmrconsulting.com/DepthOfField.pdf for an explanation of “circle of confusion”). For full-frame SLRs, a reasonable value for c is 0.03 mm, and for the smaller, DX-format SLRs, use 0.02 mm instead. If you use this formula, take care to convert all of the values to the same units!

Or, you can simply take the picture and then magnify it on your camera’s screen to see if all of the areas are acceptably sharp.

Or, you can use one of the many depth of field calculators available on the Internet (http://www.dofmaster.com/dofjs.html is a nice one).

Or, you can use one of the tables on the last page. I have provided three of them: you must use a smaller value for c for cameras with smaller image sensors. This is because images from these cameras must be enlarged more to achieve a given print (or viewing) size, making any blur in the image more visible. I’ve used values that are suitable for an 8 x 10 inch print viewed from a distance of 10 inches.

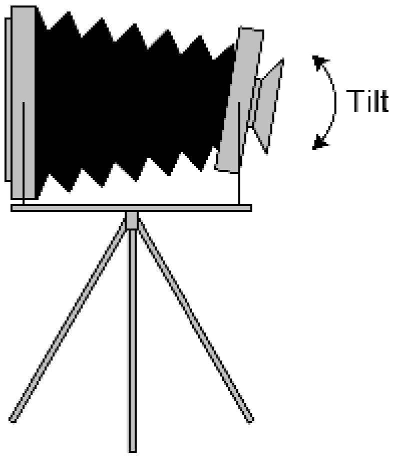
Knowing all of this, you might be tempted to simply use the smallest lens opening (largest f-number) you can all the time to achieve maximum sharpness. But there is another factor at work which contradicts this notion: diffraction. When light passes through the diaphragm (the thing that opens and closes in the lens), the rays that pass directly by the edge are diffracted (bent) to some extent (see https://en.wikipedia.org/wiki/Diffraction for another excellent article). When you use a large aperture, most of the rays going through the lens are nowhere near the diaphragm and are not diffracted. With a small aperture, however, a larger proportion of the rays are near the edge and are therefore bent, which reduces the sharpness of the image. This effect suggests using an aperture just small enough to give the required depth of field, but no smaller.



In our cameras, the plane of the lens is parallel to the sensor. The plane of exact sharp focus is therefore also parallel to the sensor.

View cameras, on the other hand, have adjustments that allow you to change the relationship between the lens and the film plane. The result of this is that the plane of sharp focus is no longer parallel to the film plane.

I have put an example on my website at http://www.kmrconsulting.com/photography/tacksharp.jpg. I made this photo with my view camera by tilting the lens forward and tilting the back (which holds the film) backward. As a result, the plane of sharp focus is right along the tops of the ferns. I used a small lens aperture to provide enough depth of field for the trees in the background (which are *not* in the plane of sharp focus) to remain sharp. This image is “tack sharp” from the nearest ferns in the foreground to the furthest trees in the background.



The reason I mention any of this is that both Canon and Nikon sell “perspective control” or “tilt-shift” lenses that gives this same capability (but to a more limited extent) to SLR users. This is the type of lens a professional would use, for example, to get a photograph of a building in which the lines do not converge toward the top of the building. (In the digital world, you can achieve the same effect with the “perspective crop tool” in Photoshop [and probably other image editing programs as well]).

Hyperfocal distance charts

Focal length (in mm) is shown across the top, f-stop is shown down the left, and the hyperfocal distance is given in feet.

Circle of confusion: 0.015 mm (Suitable for many point and shoot cameras)

	10	20	30	50	80	100	150	200	300
2	11.0	43.8	98.5	273.6	700.2	1093.9	2461.1	4375.1	9843.5
2.8	7.8	31.3	70.4	195.5	500.2	781.5	1758.1	3125.3	7031.4
4.0	5.5	21.9	49.3	136.9	350.2	547.1	1230.8	2187.9	4922.2
5.6	3.9	15.7	35.3	97.8	250.2	390.9	879.3	1563.0	3516.2
8.0	2.8	11.0	24.7	68.5	175.2	273.7	615.6	1094.3	2461.6
11.0	2.0	8.0	18.0	49.9	127.5	199.2	447.9	796.0	1790.5
16.0	1.4	5.5	12.4	34.3	87.8	137.0	308.1	547.5	1231.3
22.0	1.0	4.0	9.0	25.0	63.9	99.7	224.2	398.3	895.8
32.0	0.7	2.8	6.3	17.3	44.0	68.7	154.3	274.1	616.1

Circle of confusion: 0.020 mm (Suitable for DX-format SLRs)

	10	20	30	50	80	100	150	200	300
2	8.2	32.9	73.9	205.2	525.2	820.5	1846.0	3281.5	7382.9
2.8	5.9	23.5	52.8	146.6	375.2	586.2	1318.7	2344.1	5273.8
4.0	4.1	16.5	37.0	102.7	262.7	410.4	923.2	1641.1	3691.9
5.6	3.0	11.8	26.5	73.4	187.7	293.3	659.6	1172.4	2637.4
8.0	2.1	8.3	18.6	51.4	131.5	205.4	461.9	820.9	1846.5
11.0	1.5	6.0	13.5	37.4	95.7	149.5	336.0	597.2	1343.1
16.0	1.1	4.2	9.3	25.8	65.9	102.9	231.2	410.8	923.7
22.0	0.8	3.0	6.8	18.8	48.0	74.9	168.3	298.9	672.1
32.0	0.5	2.1	4.7	13.0	33.1	51.6	115.8	205.7	462.4

Circle of confusion: 0.030 mm (Suitable for full-frame, FX-format SLRs)

	10	20	30	50	80	100	150	200	300
2	5.5	21.9	49.3	136.9	350.2	547.1	1230.8	2187.9	4922.2
2.8	3.9	15.7	35.3	97.8	250.2	390.9	879.3	1563.0	3516.2
4.0	2.8	11.0	24.7	68.5	175.2	273.7	615.6	1094.3	2461.6
5.6	2.0	7.9	17.7	49.0	125.2	195.6	439.9	781.8	1758.6
8.0	1.4	5.5	12.4	34.3	87.8	137.0	308.1	547.5	1231.3
11.0	1.0	4.0	9.0	25.0	63.9	99.7	224.2	398.3	895.8
16.0	0.7	2.8	6.3	17.3	44.0	68.7	154.3	274.1	616.1
22.0	0.5	2.1	4.6	12.6	32.1	50.0	112.3	199.5	448.4
32.0	0.4	1.4	3.2	8.7	22.1	34.5	77.4	137.4	308.6