LEBANON CAMERA CLUB

Depth of Field Control

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3/7/2023

Depth of Field Control

Depth of field (DOF)

- Distance between the nearest and the furthest objects that are in 'acceptably sharp' focus in an image captured with a camera

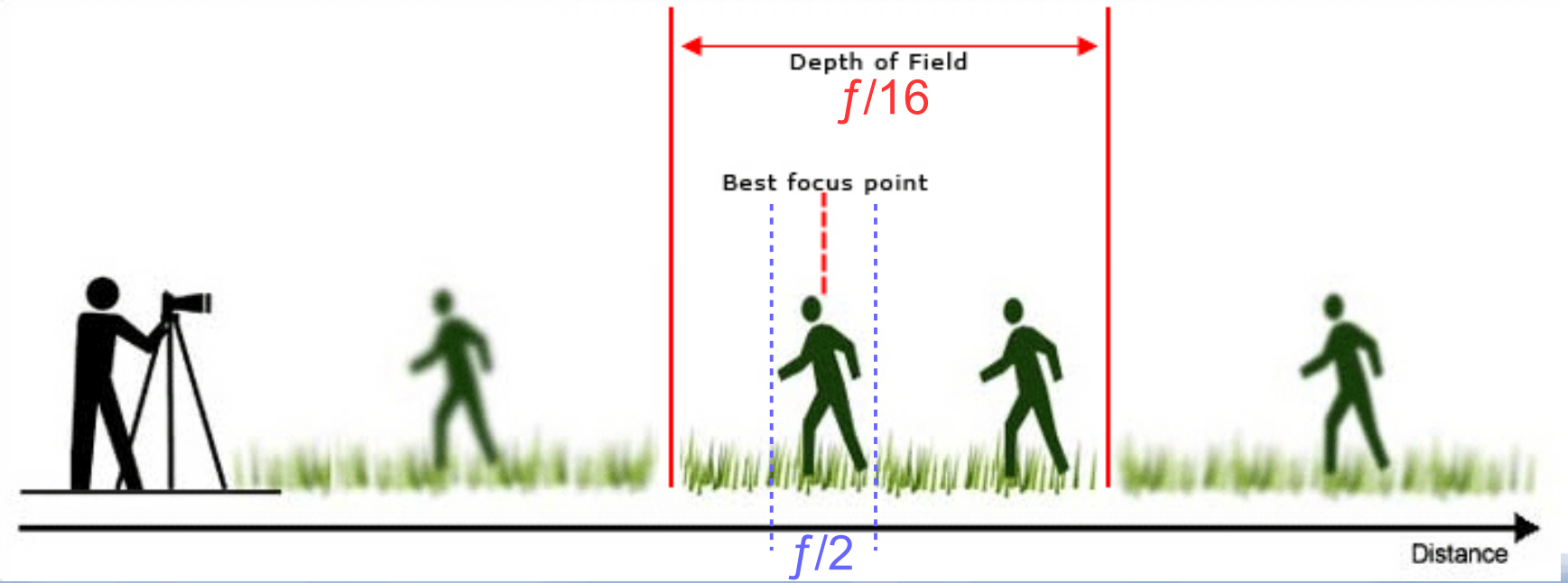
shallow depth of field
(paper at a 45° angle,
bottom closest to camera)

deep depth of field
(paper at a 45° angle,
bottom closest to camera)

Depth of Field Control

Depth of field (DOF)

- Distance between the nearest and the furthest objects that are in 'acceptably sharp' focus in an image captured with a camera
  - DOF zone boundaries are not sudden changes in sharpness
    - Sharpness transitions gradually from the best focus point
    - DOF boundaries show where the sharpness is no longer 'acceptable'



Depth of Field Control

Depth of field (DOF)

Note: Viewing conditions are things like viewing distance and lighting.

- Distance between the nearest and the furthest objects that are in 'acceptably sharp' focus in an image captured with a camera
  - Acceptably sharp → perception of sharpness (subjective)
    - Based on: visual acuity, viewing conditions, amount of enlargement
    - Expressed generally by the 'circle of confusion' for an image sensor

Sensor Size	Circle of Confusion
Four Thirds System (Olympus & Panasonic)	0.015 mm
APS-C (crop sensor)	0.018 mm
Full frame (35 mm)	0.029 mm
Medium format 645 (6 cm x 4.5 cm)	0.047 mm
Large format 4x5 (4” x 5”)	0.11 mm
Large format 8x10 (8” x 10”)	0.22 mm

Depth of Field Control

Depth of field (DOF)

- Why is it important?
  - Affects subject prominence
    - Always want the subject in focus
    - Background may be a distraction → prefer it to be blurred
  - DOF needs may be different depending on the subject

Photo Type	Subject	Background	Depth of Field
portrait	face, or just eyes	heavily blurred	very shallow
fashion	body + hair + clothes	blurred	shallow
still life	items on table	some blur	shallow to moderate
street	people + environment	some blur okay	moderate
landscape	entire scene		deep
macro	entire scene		deep (never enough)

Depth of Field Control

Note: Photo by Ed Verosky

Depth of field (DOF)

- Portrait examples
  - Eyes only

Depth of Field Control

Note: Photo by Jane Allan

Depth of field (DOF)

- Portrait examples
  - Face only

Depth of Field Control

Note: Photos by Vit Kovalcik

Depth of field (DOF)

- Portrait examples
  - Background blur
    - Large aperture (small f-number) → more blur
    - Small aperture (big f-number) → less blur

Note: Out-of-focus features can appear brighter because blurred elements are larger and contrast is lower (small dark areas are obscured by blurred bright areas).

f/1.8 → large aperture, significant blur

f/16 → small aperture, much less blur

Depth of Field Control

Depth of field (DOF)

Note: Some landscape photographers may use a shallow DOF for a landscape scene if they want to draw attention to a specific feature.

- Landscape example
  - Want the whole scene in focus (if possible)
    - A person looking at a landscape scene will see everything in focus
    - The eye automatically refocuses when looking at different elements

landscape images often feature a foreground object to give depth to the image → this should be as sharp as the rest of the scene, which requires very large DOF...

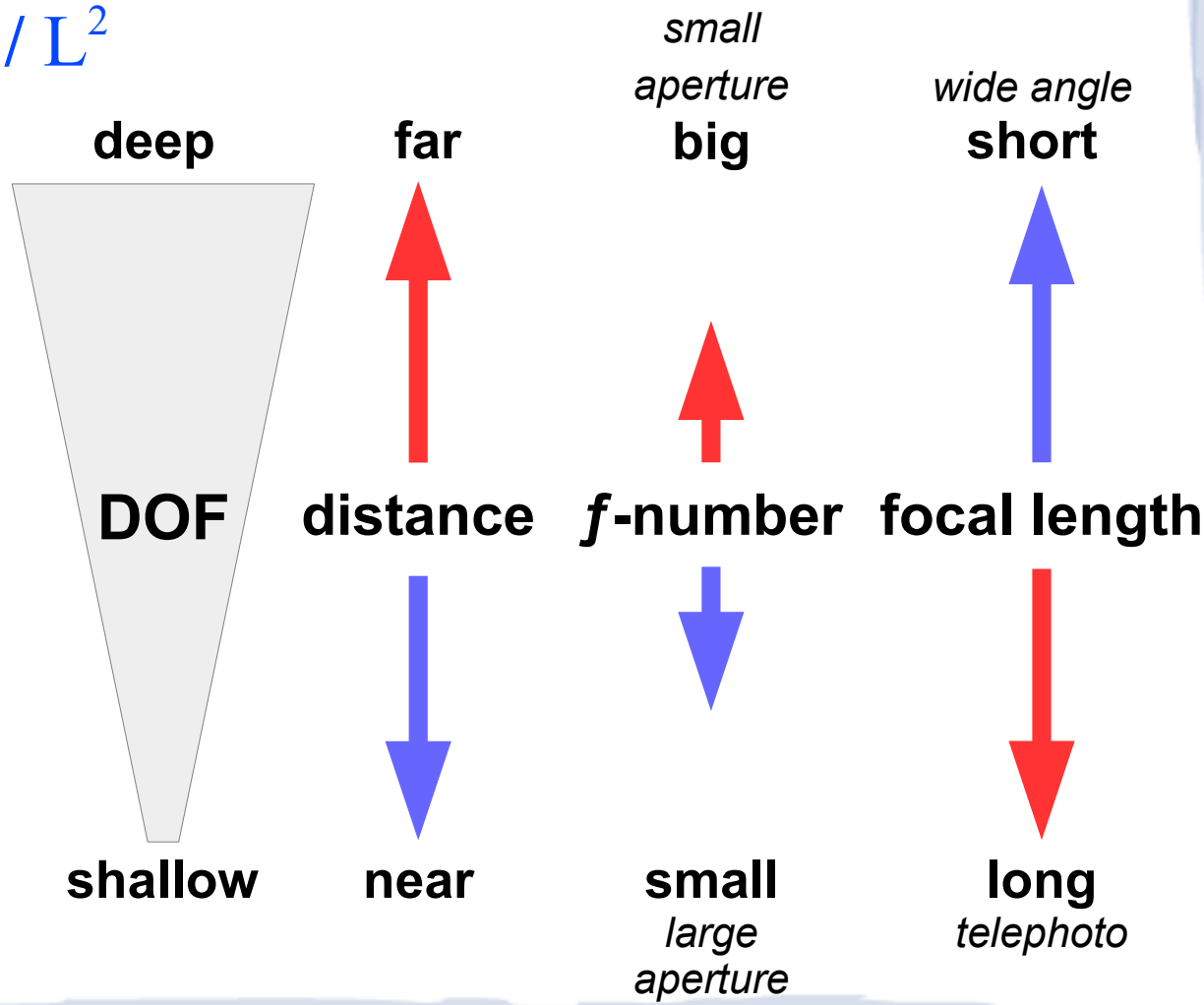
...it's possible to 'cheat' by compositing two images with smaller DOF, but it's usually not easy

Depth of Field Control

Depth of field (DOF)

- Formula
  - $DOF \approx (2 \cdot d^2 \cdot f \cdot c) / L^2$
    - d = distance to subject
    - f = f-number
    - c = circle of confusion
    - L = lens focal length

Note: circle of confusion is fixed for a specific camera, so it's effect is ignored here → it is only relevant if you are choosing between cameras with a different sensor sizes.



Note: distance and focal length contribute more to DOF than f-number because those values are squared, but they usually offset each other → longer focal length means more distance to subject for the same framing

Depth of Field Control

Note: Photos by Elizabeth Gray

Depth of field (DOF)

- Focal length effects
  - Angle of view change
    - Longer focal length → less background visible
  - Compression
    - Longer focal length → background appears closer

Note: Standing close to a subject when using a wide angle lens can result in facial distortion → a telephoto lens renders a more natural face

24 mm focal length

300 mm focal length

Depth of Field Control

Note: Photos by Elizabeth Gray

Depth of field (DOF)

Note: The total DOF for 24 mm @ 6 ft = 9 ft, but the total DOF for 300 mm @ 75 ft (equal subject size) = 6.3 ft. We'll see why in a bit...

- DOF asymmetry
  - Sometimes similar in front and behind the focus point
  - Other times more DOF behind the focus point
    - 24 mm, *f*/5.6, 6 ft to subject → 2 ft in front, 7 ft behind
    - 300 mm, *f*/5.6, 75 ft to subject → 3 ft in front, 3.3 ft behind

24 mm focal length

300 mm focal length

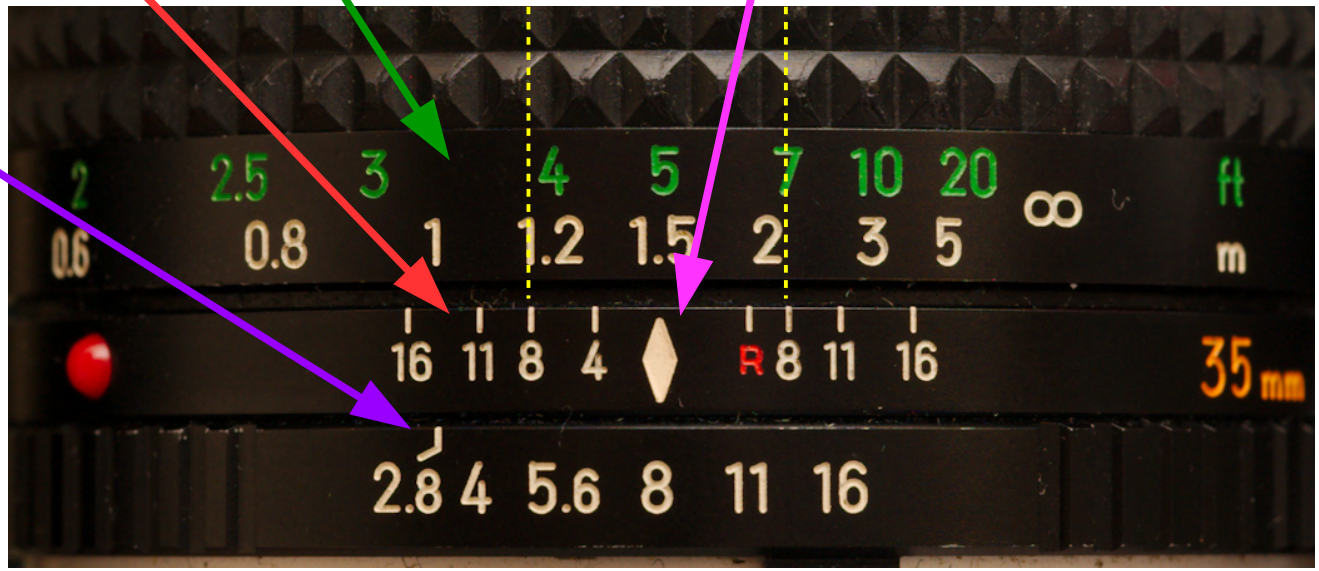
Depth of Field Control

Achieving desired DOF

Note: Unfortunately these markings are often missing on modern lenses, and manufacturers usually do not supply equivalent information on the LCD.

- Lens markings
  - Some lenses have features that help with DOF control
    - Focus distance scale (feet and meters)
    - DOF markings
    - Aperture ring

selected aperture and focus distance marker



indicated DOF is a bit less than 4 ft to 7 ft = ~3.1 ft

The focus distance scale is not linear which makes estimating the actual DOF tricky, and often there are no DOF markings for larger apertures (*f*/2.8, *f*/2, *f*/1.4). But it's better than nothing.

Depth of Field Control

Achieving desired DOF

Note: This worked for nature and landscape photography, where scenes are static and there is plenty of time to refer to the chart.

- Charts
  - In 2006 I created DOF charts for use in the field
    - Focal length; circle of confusion value (x1000); *f*-numbers
    - Focus distances (meters); near DOF distances; far DOF distances

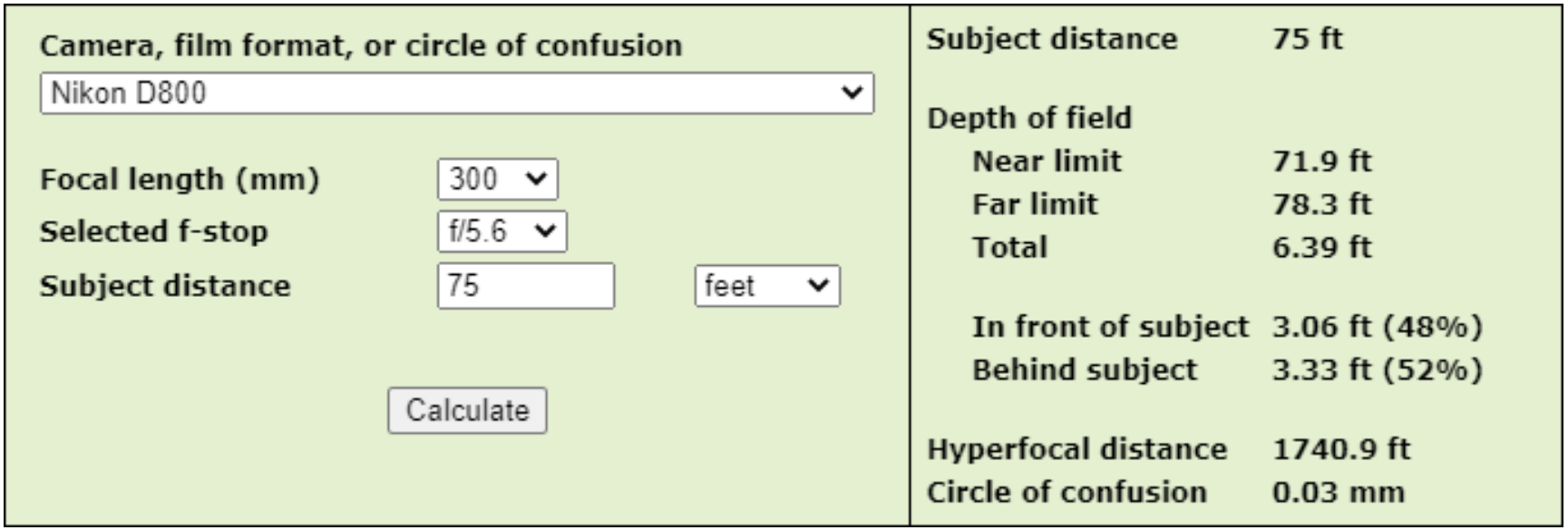
50	11.0	2.828	2.828	4.000	4.000	5.657	5.657	8.000	8.000	11.31	11.31	16.00	16.00	22.63	22.63	32.00	32.00	64.00	64.00	128.0	128.0
	2.8	2.732	2.931	3.810	4.210	5.285	6.085	7.276	8.885	9.918	13.17	13.34	19.98	17.66	31.50	22.89	53.18	35.63	314.5	49.36	∞
	3.2	2.721	2.944	3.788	4.237	5.243	6.142	7.196	9.007	9.770	13.44	13.08	20.61	17.19	33.08	22.11	57.87	33.79	603.9	45.91	∞
	3.6	2.708	2.959	3.764	4.268	5.196	6.208	7.108	9.147	9.609	13.75	12.79	21.36	16.70	35.07	21.31	64.23	31.94	∞	42.57	∞
	4.0	2.694	2.976	3.737	4.303	5.145	6.283	7.013	9.311	9.435	14.13	12.48	22.27	16.18	37.60	20.47	73.26	30.10	∞	39.35	∞
	4.5	2.678	2.995	3.707	4.343	5.088	6.369	6.908	9.50	9.247	14.57	12.16	23.39	15.64	40.92	19.61	87.00	28.26	∞	36.27	∞
	5.0	2.661	3.017	3.674	4.389	5.026	6.468	6.795	9.73	9.045	15.10	11.81	24.80	15.07	45.41	18.72	110.2	26.46	∞	33.35	∞
	5.7	2.642	3.042	3.638	4.442	4.959	6.584	6.672	9.99	8.828	15.75	11.44	26.59	14.47	51.80	17.81	157.2	24.68	∞	30.58	∞
	6.3	2.621	3.071	3.598	4.503	4.885	6.719	6.539	10.30	8.597	16.54	11.06	28.93	13.86	61.51	16.90	302.0	22.96	∞	27.97	∞
	7.1	2.598	3.103	3.554	4.574	4.805	6.877	6.396	10.68	8.351	17.54	10.65	32.11	13.24	77.91	15.97	∞	21.28	∞	25.53	∞
	8.0	2.572	3.141	3.506	4.655	4.718	7.064	6.242	11.14	8.092	18.80	10.24	36.63	12.60	111.2	15.05	∞	19.68	∞	23.25	∞
	9.0	2.544	3.184	3.454	4.751	4.624	7.285	6.079	11.70	7.819	20.46	9.803	43.50	11.95	213.5	14.13	∞	18.14	∞	21.13	∞
	10.1	2.513	3.234	3.397	4.863	4.522	7.552	5.905	12.40	7.534	22.71	9.359	55.09	11.29	∞	13.23	∞	16.67	∞	19.17	∞
	11.3	2.479	3.291	3.336	4.995	4.414	7.875	5.721	13.29	7.238	25.90	8.906	78.62	10.64	∞	12.34	∞	15.29	∞	17.36	∞
	12.7	2.442	3.359	3.269	5.151	4.298	8.272	5.529	14.47	6.932	30.76	8.448	151.0	9.993	∞	11.48	∞	13.99	∞	15.70	∞
	14.3	2.402	3.438	3.198	5.340	4.176	8.768	5.327	16.06	6.618	38.96	7.986	∞	9.353	∞	10.64	∞	12.76	∞	14.18	∞
	16.0	2.358	3.531	3.121	5.568	4.046	9.401	5.118	18.32	6.298	55.60	7.524	∞	8.726	∞	9.838	∞	11.62	∞	12.79	∞
	18.0	2.311	3.642	3.039	5.849	3.909	10.23	4.901	21.75	5.973	106.8	7.066	∞	8.116	∞	9.069	∞	10.57	∞	11.52	∞
	20.2	2.261	3.775	2.952	6.200	3.767	11.35	4.679	27.55	5.647	∞	6.614	∞	7.525	∞	8.337	∞	9.586	∞	10.36	∞
	22.6	2.207	3.936	2.861	6.647	3.619	12.95	4.453	39.31	5.321	∞	6.171	∞	6.956	∞	7.645	∞	8.682	∞	9.313	∞

Depth of Field Control

Achieving desired DOF

Note: Charts and calculators require that you know the focus distance. If your camera/lens does not tell you, you have to measure or estimate.

- Calculators
  - DOFMaster: www.dofmaster.com
    - Standalone program and online calculator

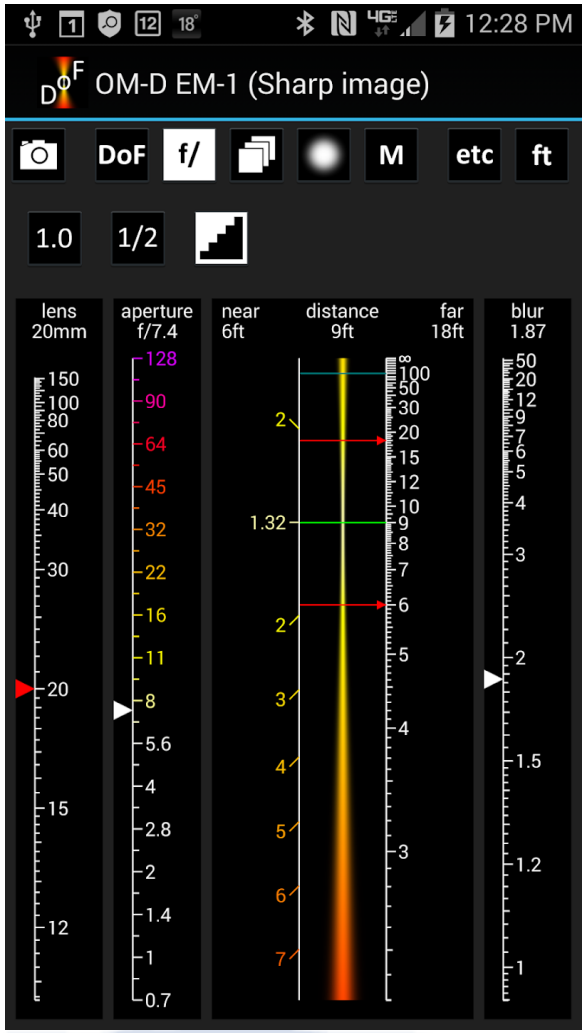


Depth of Field Control

Achieving desired DOF

- Calculators
  - Cell phone and tablet apps
    - Many available for Android and iPhone/iOS

Note: Charts and calculators require that you know the focus distance. If your camera/lens does not tell you, you have to measure or estimate.



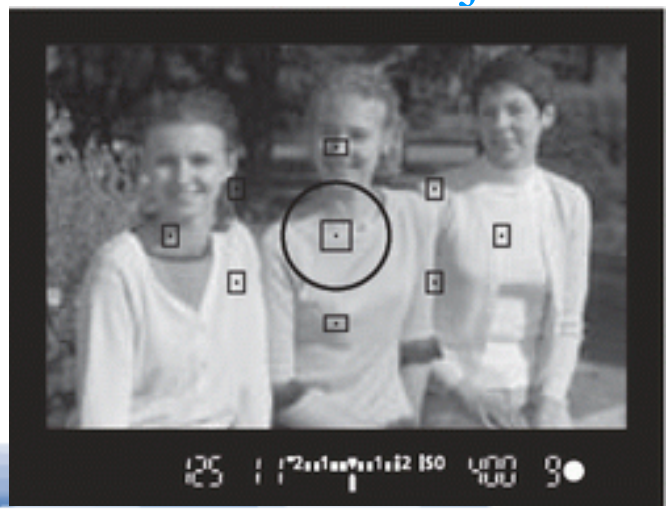
'DOF' app, Android, free

Depth of Field Control

Achieving desired DOF

Note: Error messages if the DOF cannot be obtained. Unclear what happens when one of the AF points is not on a subject, or if AF points can be selected.

- Camera
  - Canon A-DEP mode (Automatic Depth-of-Field AE)
    1. Set the mode dial to A-DEP
    2. Focus the subject
       - ➔ Aim the AF points over the subjects and half press the shutter
       - ➔ All the subjects covered by AF points flashing red will be in focus
    3. Take the picture
    - Error messages if the DOF cannot be obtained
    - Unclear what happens if one or more AF points is not on a subject
  - Better implementation (doesn't exist ?)
    - Single focus point
    - Set amount of DOF
    - After focusing camera sets *f*-number

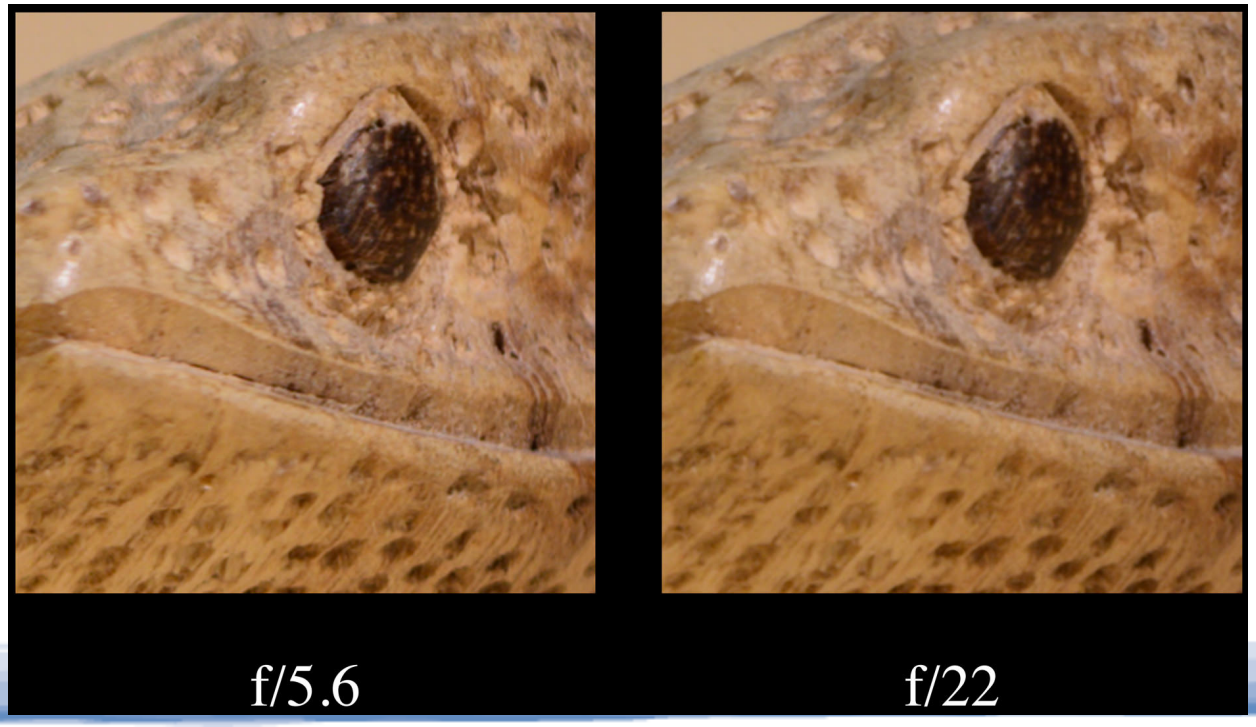


Depth of Field Control

Achieving desired DOF

Note: Diffraction can be mitigated somewhat by sharpening, but over-sharpening introduces it's own artifacts.

- Diffraction: the fly in the ointment
  - As the aperture gets smaller the image become more blurred
    - More blur everywhere, even at the best focus point
    - Due to the diffraction of light waves through a small opening
    - Exists at every aperture, but is insignificant at larger apertures
    - Introduces a trade-off between DOF and diffraction



Depth of Field Control

Achieving desired DOF

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- Diffraction: the fly in the ointment
  - As the aperture gets smaller the image become more blurred
    - More blur everywhere, even at the best focus point
    - Due to the diffraction of light waves through a small opening
    - Exists at every aperture, but is insignificant at larger apertures
    - Introduces a trade-off between DOF and diffraction
  - When diffraction becomes noticeable (rule of thumb)
    - Full frame: *f*/11 (slight), *f*/16 (obvious)
    - APS-C: *f*/8 (slight), *f*/11 (obvious)
    - 4/3 system: *f*/5.6 (slight), *f*/8 (obvious)

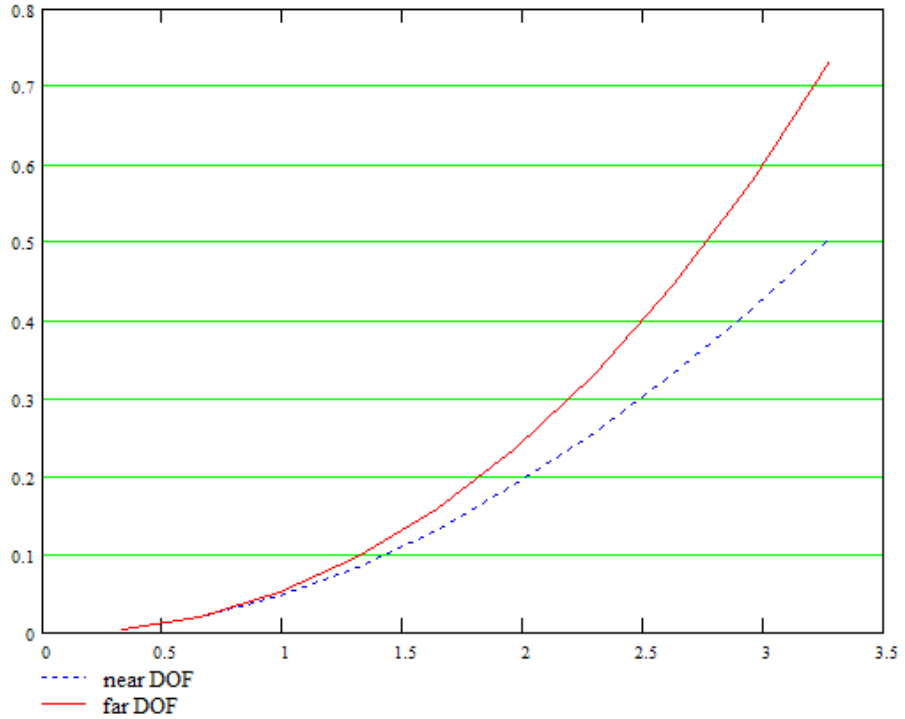
Depth of Field Control

Hyperfocal distance

- DOF asymmetry
  - Focus dist. approaches a key value → far DOF goes way up
    - In fact, it goes to infinity at what is called the "hyperfocal distance"

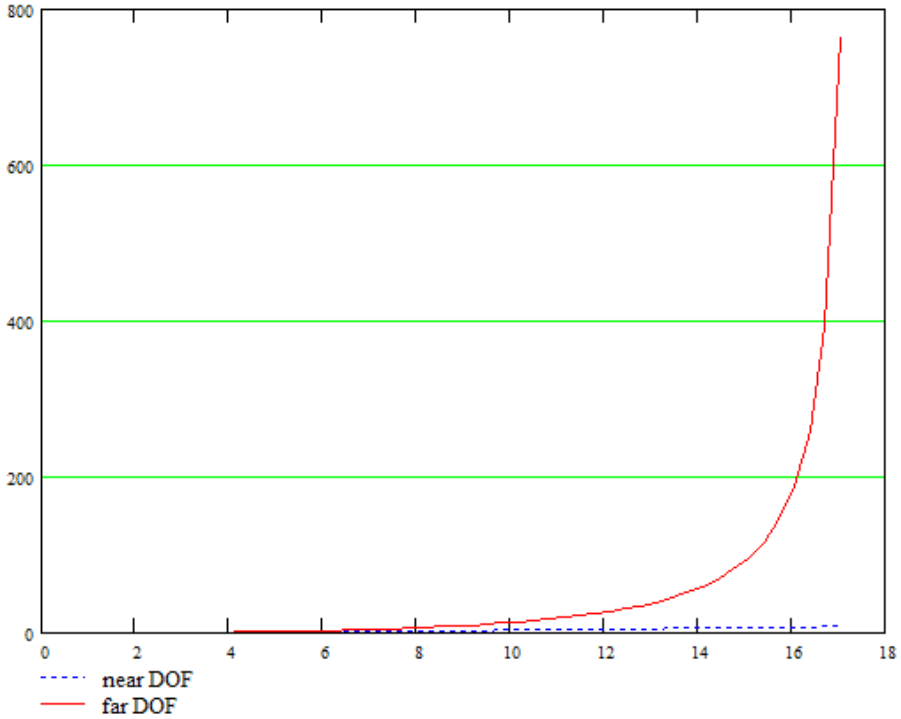
Note: The hyperfocal distance (HD) depends on lens focal length, f-number, and circle of confusion. At the HD, the DOF is the maximum for those parameters.

35 mm focal length, $f/8$



← subject distance in feet →

35 mm focal length, $f/8$



← subject distance in feet →

Depth of Field Control

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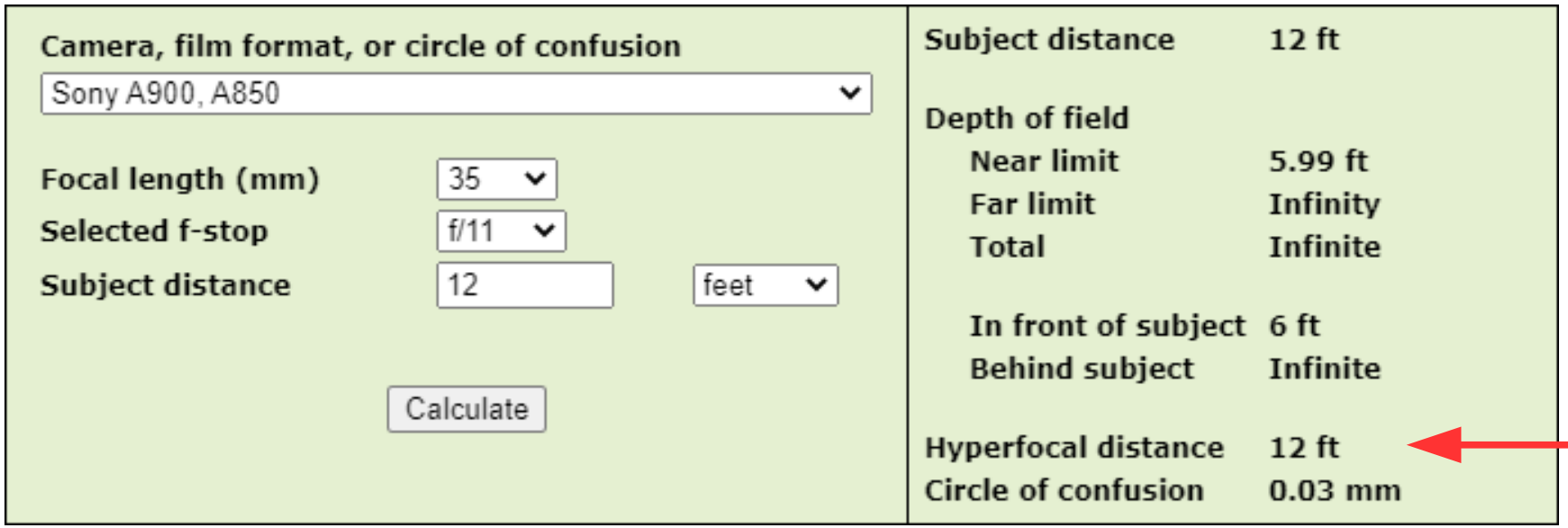

Depth of Field Control

Hyperfocal distance

- DOF asymmetry
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Note: The markings on a lens designed for a 35mm film camera are not accurate for a crop sensor digital camera because the circle of confusion is different.

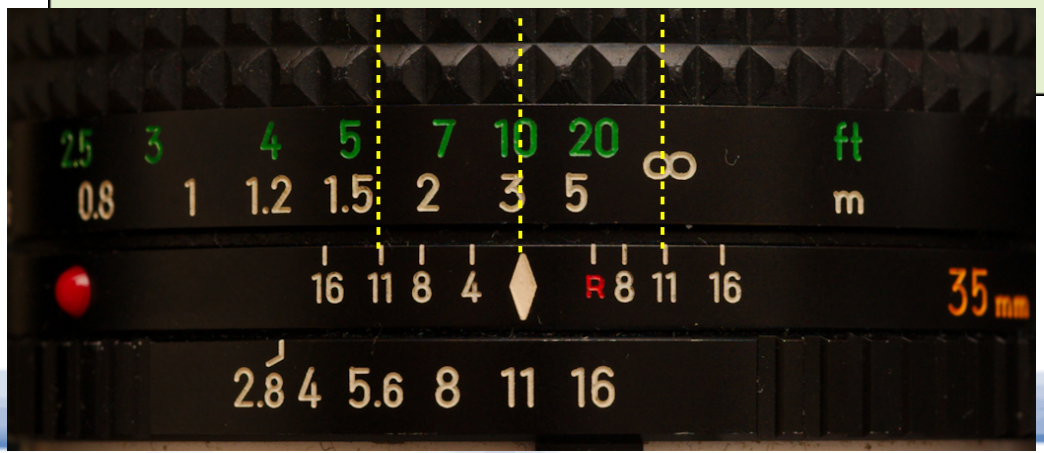
Camera, film format, or circle of confusion

Sony A900, A850

Focal length (mm)	35	
Selected f-stop	f/11	
Subject distance	12	feet

Calculate

Subject distance	**12 ft**
Depth of field	
Near limit	**5.99 ft**
Far limit	**Infinity**
Total	**Infinite**
In front of subject	**6 ft**
Behind subject	**Infinite**
Hyperfocal distance	**12 ft**
Circle of confusion	**0.03 mm**



Depth of Field Control

Hyperfocal distance

Note: Optimal focus only occurs at the subject distance → although objects at infinity may not be as sharp, they are still 'acceptably sharp' (depending on viewing conditions)

- Landscape example
  - Want the whole scene in focus (if possible)
    - A person looking at a landscape scene will see everything in focus
    - The eye automatically refocuses when looking at different elements

landscape images often feature a foreground object to give depth to the image → this should be as sharp as the rest of the scene, which requires very large DOF...

Depth of Field Control

Hyperfocal distance

Note: If you reduce the subject distance from the hyperfocal value you will get a closer near DOF and sacrifice some far DOF (a lot if you move far from the HD).

- Street photography example
  - Don't want to take time to focus (or don't want camera at eye level)
    - Use manual focus, set your lens to a HD → a large in-focus range
    - Example: FF camera, 35mm lens, *f*/11 → DOF = 6.33 ft to ∞
    - You can reduce the subject distance to get closer focus (or increase *f*-#)

hyperfocal distance chart for 35mm (full frame) sensor cameras

	f-number									
	1.4	**2**	**2.8**	**4**	**5.6**	**8**	**11**	**16**	**22**	
14	15.8	11.1	7.92	5.54	3.96	2.77	2.02	1.39	1.01	**14**
near	*7.93*	*5.55*	*3.97*	*2.78*	*1.99*	*1.40*	*1.02*	*0.70*	*0.52*	*near*
16	20.7	14.5	10.3	7.24	5.17	3.62	2.63	1.81	1.32	**16**
near	*10.4*	*7.25*	*5.18*	*3.63*	*2.60*	*1.82*	*1.33*	*0.92*	*0.67*	*near*
18	26.2	18.3	13.1	9.16	6.55	4.58	3.33	2.29	1.67	**18**
near	*13.1*	*9.18*	*6.56*	*4.60*	*3.29*	*2.31*	*1.68*	*1.16*	*0.85*	*near*
21	35.6	24.9	17.8	12.5	8.91	6.24	4.54	3.12	2.27	**21**
near	*17.8*	*12.5*	*8.93*	*6.25*	*4.47*	*3.14*	*2.29*	*1.58*	*1.15*	*near*
24	46.5	32.6	23.3	16.3	11.6	8.15	5.92	4.07	2.96	**24**
near	*23.3*	*16.3*	*11.7*	*8.17*	*5.84*	*4.09*	*2.98*	*2.06*	*1.50*	*near*
28	63.4	44.3	31.7	22.2	15.8	11.1	8.06	5.54	4.03	**28**
near	*31.7*	*22.2*	*15.9*	*11.1*	*7.94*	*5.57*	*4.05*	*2.79*	*2.04*	*near*
35	99.0	69.3	49.5	34.6	24.7	17.3	12.6	8.66	6.30	**35**
near	*49.5*	*34.7*	*24.8*	*17.4*	*12.4*	*8.69*	*6.33*	*4.36*	*3.18*	*near*

You can get hyperfocal distance charts from DOFMaster.com, and DOF apps show the hyperfocal distance–but I wanted to know the HD and the near focus distance so I made my own chart (I'll make a PDF available so you can print your own)

Depth of Field Control

Hyperfocal distance

- Focal length effects
  - Telephoto lens hyperfocal distances are very large
    - Scales as the focal length squared
    - Still can be useful for sports

85	584	409	292	204	146	102	74.3	51.1	37.2	**85**
near	*292*	*204*	*146*	*102*	*73.1*	*51.2*	*37.2*	*25.6*	*18.6*	*near*
100	808	566	404	283	202	141	103	70.7	51.4	**100**
near	*404*	*283*	*202*	*141*	*101*	*70.8*	*51.5*	*35.4*	*25.8*	*near*
135	1473	1031	736	515	368	258	187	129	93.7	**135**
near	*736*	*516*	*368*	*258*	*184*	*129*	*93.8*	*64.5*	*47.0*	*near*
150	1818	1273	909	636	455	318	231	159	116	**150**
near	*909*	*636*	*455*	*318*	*227*	*159*	*116*	*79.7*	*58.0*	*near*
200	3232	2263	1616	1131	808	566	411	283	206	**200**
near	*1616*	*1131*	*808*	*566*	*404*	*283*	*206*	*142*	*103*	*near*
250	5051	3535	2525	1768	1263	884	643	442	321	**250**
near	*2525*	*1768*	*1263*	*884*	*632*	*442*	*322*	*221*	*161*	*near*
300	7273	5091	3636	2545	1818	1273	926	636	463	**300**
near	*3637*	*2546*	*1818*	*1273*	*909*	*637*	*463*	*318*	*232*	*near*
	1.4	**2**	**2.8**	**4**	**5.6**	**8**	**11**	**16**	**22**	
	distances are in feet									

Depth of Field Control

Shooting considerations

Note: Even if you tend to shoot dynamic subjects, it's a good idea to try some deliberate shooting where you think about each step of the process → it helps 'train' your photographic mind.

- Process
  1. Pick your subject
  2. Decide on your composition
     - Includes angle of view and compression effect → focal length
     - Affects where you can stand → subject distance and focal length
  3. Decide what you want in focus
     - May affect → focal length and/or subject distance
     - Definitely affects → *f*-number
  4. Be mindful of shutter speed
     - May need to adjust ISO—remember that ISO affects noise
- Photography is a balancing act → all about trade-offs
  - It may seem complicated at first (and maybe tedious)
  - But as you gain experience the process becomes automatic

Depth of Field Control

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