

12. Exposure

Wednesday, October 4, 2023 5:36 PM

Today:
Admin
Exposure
Aperture
Shutters
Sensitivity: ISO

'Every day
I see or hear
something
that more or less
kills me
with delight,
that leaves me
like a needle
in the haystack
of light.'
From 'Mindful' (2004) by American poet Mary Oliver.

Clickers

Admin

Tomorrow at Denver Museum of Nature and Science
Cloudspotting by Gavin Pretor-Pinney, founder of the Cloud Appreciation Society. 7 pm

Team Critiques:

- a) Keep presentations in teams together *5270*
- b) Mix it up - I don't need to present with my team *4870*
- c) Mix it up - I want to see a wider variety of work
- d) Other

4. EXPOSURE

For a given light intensity, exposure = Total photons hitting the sensor: (aperture area) X (time shutter is open)

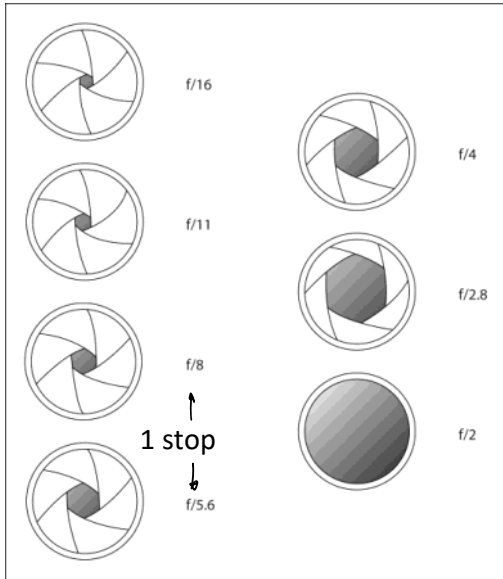
Aperture

$$f/\text{ } = \frac{f}{D} = \frac{\text{focal length}}{\text{aperture diameter}}$$

Aperture has impact on exposure too, how much light total hits the sensor.

- Exposure units: 1 stop = 1 EV Exposure Value = factor of 2 in area, or total light.
Camera adjustments in 1/3 or 1/2 stop steps

Stop used to be a metal plate with hole punched in it. It stopped light.



Aperture (iris) mechanism made from overlapping pivoting leaves.

http://media.wiley.com/assets/1007/41/0-7645-9802-3_0213.jpg



F-stop series, 1 stop increments: 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, 32, 45, 64
WRITE THIS DOWN, we'll use in a few minutes

Shutter Speed

Shutter speeds: 30 = 1/30th of a second etc.

5 = 1/5th of a second

30" = 30 seconds

T = time, click to open shutter and again to close

B = bulb, shutter stays open as long as button is pressed (or bulb is squeezed)

2 →
4 →

make a long time exposure

In groups:

Check your camera shutter speed options. What is the range?

Shutter Speed
Longest
 1
 30"

Proper exposure = middle value on an average pixel

Same image brightness
 f/5.6, 1/100 sec, ISO 200
 f/8, 1/100 sec, ISO 400
 f/4, 1/200 sec, ISO 400

OK, many combinations lead to the same overall brightness. How to choose?

In groups, what are the side effects of each choice?

Next class we fill those out

Side Effects	If you want your photo		Side Effects
	Darker	Brighter	
DOF ↑	Aperture f/8 f/5.6 f/4 f/2.8 f/2.0 f/1.4		DOF ↓ Bokeh
	Shutter Speed Fast 1/1000 sec Medium 1/250 sec Slow 1/30 sec		motion blur
	ISO Sensitivity Low gain ISO 100 High gain ISO 6400		noise

Mechanical vs Electronic (rolling) Shutters

Advantages to Using A Mechanical Shutter

- Sync better with flash – mechanical shutters tend to allow you to operate the flash at higher speeds than an electronic shutter
- ~~Reduce rolling shutter in shutterless cameras~~
- Reduce Rolling Shutter distortions – Rolling shutters (a type of electronic shutter) can often result in lateral distortion of images especially when the camera is panned quickly, or a subject is on motion.
- They cope better than electronic shutter with flickering light sources

Disadvantages of Using A Mechanical Shutter

- Reduced Top Shutter Speed – The mechanical nature of these kinds of shutters means that the maximum speed is usually less than electronic shutters
- They have a life span – as mechanical shutters feature moving parts these are obviously prone to wear and tear and may stop working overtime. Most cameras that come with a mechanical shutter system will have a "shutter count" or number of times the shutter can be used before it might start to fail.
- Camera shake – The movement of the shutter doors and mirrorbox can cause minor camera shake although inbuilt image stabilisation can help reduce this.
- Response Time – Again due to the mechanical nature of the shutters there can be a minor delay between pressing the shutter button and the camera taking the photo.

Advantages to Using Electronic Shutters

- They are silent – without the moving parts of a mechanical shutter the camera is silent which is great for wildlife photographers and other situations when you need to not make any noise.
- Faster shutter speeds – electronic shutters eliminate the mechanical shutter delay meaning that a shutter speed of 1/32000th second is not that unusual.
- Higher continuous shooting rates – as the camera doesn't need to wait for the mirror and shutters to physically reset it can be ready to take the next photo quicker.
- No more blackout – as these cameras use an electronic viewfinder you can continue to see through the viewfinder through the shot which is great for long exposures, panning and continuous shooting.

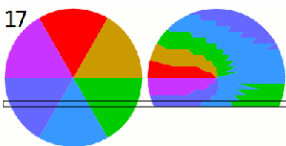
Disadvantages of Using Electronic Shutters

- Potential for Banding and jelly-like distortion in rolling shutters – this is especially prevalent in fast moving subjects and during panning.
- Flickering light banding – electronic shutters don't always cope with flickering light sources and often banding can be seen which is difficult to remove.
- Slow flash sync speeds – while you can still sync flashes with cameras using electronic shutters the top sync speed is generally much lower.
- Obstructed use – in some cameras, using the electronic shutter can stop you from using some features of the camera.

<https://photodoto.com/here-is-why-mirrorless-cameras-have-shutters/>

Physically protect the sensor from intense light

17



https://commons.wikimedia.org/wiki/File:Rolling_shutter_effect_animation.gif

Electronic shutters do this all the time.
 Mechanical shutters do this at speeds above the sync speed, > 1/60th sec typically
 Flash illumination only works for speeds < sync.

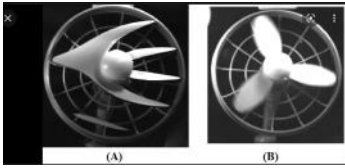


Fig 3.18 Global shutter (B) versus rolling shutter (A) and motion blur distortion [84]

From <https://www.researchgate.net/publication/242404501>
[Foveated Sampling Architectures for CMOS Image Sensors/figures?from=publication](https://www.researchgate.net/publication/242404501/figure/figs/figure-figures?from=publication)

Mechanical shutter operation:
https://www.youtube.com/watch?v=YNhakG6_RBk
 2:08 - 2:52
https://commons.wikimedia.org/wiki/File:SLR_-_DSLR_optical_diagram_07.gif



~95% of digital cameras have rolling shutters. Maybe 5% have global shutters; whole sensor is turned on and off at once, then read off line by line. Slower than rolling shutter. Industrial/pro use only. But this could change in the next few years!

Exposure

Put it together: exposure = Total photons hitting the sensor: (aperture area) X (time shutter is open)

Equivalent exposures:
 f/5.6, 1/100 sec
 f/8, 1/50 sec
 Think pair share, what's next in this sequence?

f/11 1/65
f/16 1/40

The effect of those photons depends on the sensor (CCD, CMOS etc) that converts photons into numbers (three, for RGB) for each pixel

ISO = sensor sensitivity, gain
 1 EV = 1 stop = factor of 2 in ISO
 100 200 400 800

Check your camera ISO settings. How easy to change?

1. Have ISO button *65%*
2. Thumbwheel *25%*
3. In a menu *5%*
4. mysterious *5%*

2022	2023
39%	X
39%	X
17%	X
4%	x

What is the highest ISO your camera has?

102,400 204k
6400
25,600 X3

Used to be hard to change sensitivity, ISO: change film or go into menus.
 Now is becoming easier; single button or thumbwheel select.

Sensors respond ~ linearly up to a certain ISO. Above that, numbers aren't given, instead rated as H, H2 etc.

The ISO sensitivity of a digital sensor works in a slightly different way to film. A film rated at 200 ISO is physically different to a film rated at 800 ISO, whereas a digital sensor is the same regardless of the ISO setting used in the camera. All digital sensors have a base ISO setting but to achieve higher ISO settings the sensitivity of the sensor is increased.

The sensitivity of a camera sensor is increased in steps which correspond to ISO settings i.e. ISO 100, ISO 200, ISO 400, ISO 800 etc. The difference between ISO 100 and ISO 200 is that ISO 200 is twice as sensitive as ISO 100 (or 1 stop difference). This is also the same between ISO 200 and ISO 400 (1 stop difference).

When increasing a digital camera's ISO sensitivity by a large amount the sensor may perform slightly differently to the ISO standard for that ISO speed. Due to this we rename these settings as Hi 1, Hi 2 or Hi 3 instead of actually naming the sensors ISO setting. Whilst the camera is often performing at levels far past available film speeds, the performance of the sensor, in relation to how much light is needed to expose correctly, may differ by a very small amount to the level expected at that ISO setting.

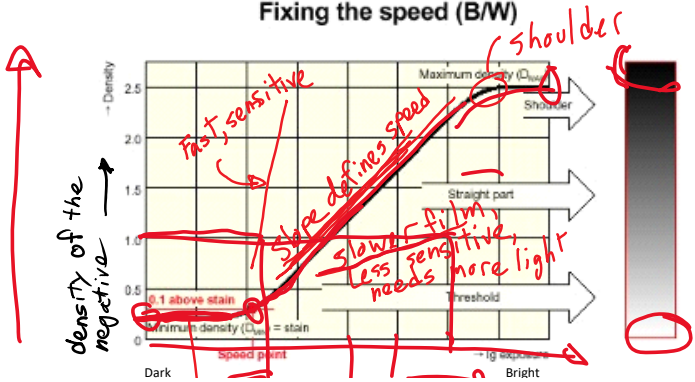
From https://www.nikonimgsupport.com/na/NSG_article?articleNo=000027508&configured=1&lang=en_SG

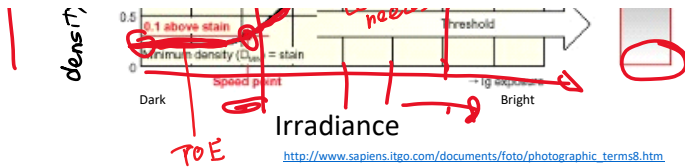
Sensitivity measure used to be called ASA for film.

From [American Standards Association](https://www.ansi.org/) (now named [ANSI](https://www.ansi.org/))

ISO = International Organization for Standardization

Fixing the speed (B/W)





Now, digital photography:

Have you been taught to count in binary or base 8 or 16?

Where?	2022	2023
College math class	10%	10
College computer science class	30%	20
Other college class	30%	26
K-12 school	20	30
Never	10	15

Digital colors are usually expressed in hexadecimal, base 16:

Decimal 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Hex 0 1 2 3 4 5 6 7 8 9 A B C D E F

Bit = 0 or 1

Byte = 8 bits.

One digit in hexadecimal is $2^4=16$ = a nibble

Byte = $2^8 = 256$, FF in hexadecimal

Hex decimal

0F = $16 - 1 = 15$

10 = 16

1F = $16 + 15 = 31$

23 = $2 * 16 + 3 = 35$

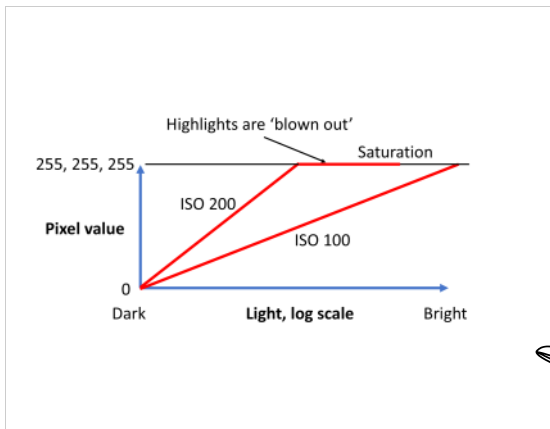
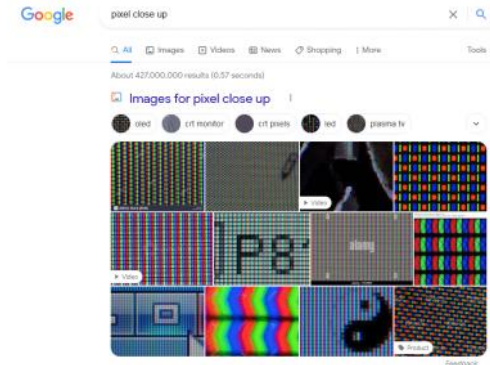
FF = $16 * 16 - 1 = 255$ = highest we can count using 2 'digits'. 0 to 255 = range of 256 levels.

RGB

What color does a pixel value of FF FF FF correspond to?

1. Black
2. White
3. Neutral gray
4. Pure red
5. No idea

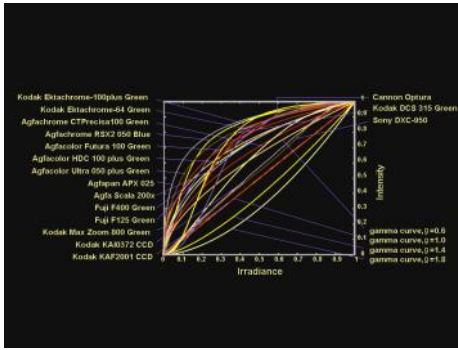
2023 2022
43% 14%
52% 67%
30%
4% 14%



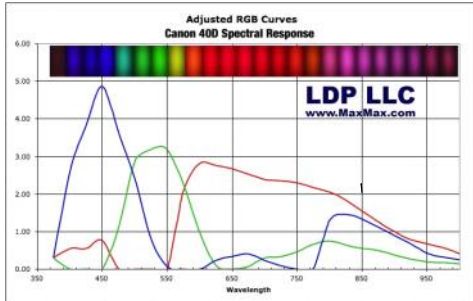
Ideal response.
Real response

Digital camera response database

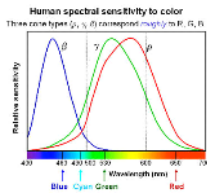




http://www.cs.columbia.edu/CAVE/projects/rad_cal/



http://www.maxmax.com/spectral_response.htm



<http://pixinsight.com/forum/index.php?topic=2542.0>

Excellent book on how human eyes work, for nonspecialists: Livingstone, Margaret S. *Vision and Art: The Biology of Seeing*. Abrams, 2008.

Don't worry, images come from camera with compensation done automatically (mostly); color management again.

Proper exposure = middle value on an average pixel

Same image brightness
 f/5.6, 1/100 sec, ISO 200
 f/8, 1/100 sec, ISO 400
 f/4, 1/200 sec, ISO 400

OK, many combinations lead to the same overall brightness. How to choose?

In groups, what are the side effects of each choice?

Side Effects	If you want your photo		Side Effects
	Darker	Brighter	
	<p>Aperture</p> <p>f/8 f/5.6 f/4 f/2.8 f/2.0 f/1.4</p>		
	<p>Shutter Speed</p> <p>Fast Medium Slow</p> <p>1/1000 sec 1/250 sec 1/30 sec</p>		
	<p>ISO Sensitivity</p> <p>Low gain High gain</p> <p>ISO 100 ISO 6400</p>		

Exposure Conclusion

Proper exposure = middle value on an average pixel

Same image brightness
 f/5.6, 1/100 sec, ISO 200
 f/8, 1/100 sec, ISO 400
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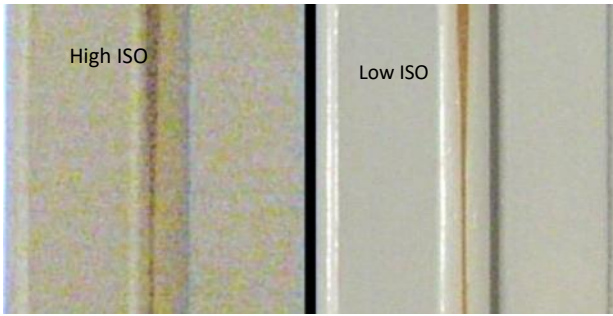
OK, many combinations lead to the same overall brightness. How to choose?

In groups, what are the side effects of each choice?

Side Effects	If you want your photo		Side Effects
	Darker	Brighter	
Large D.O.F. Reduced Sharpness	<p>Aperture</p> <p>f/8 f/5.6 f/4 f/2.8 f/2.0 f/1.4</p>		Narrow D.O.F.
Freeze motion Rolling Shutter Artifact	<p>Shutter Speed</p> <p>Fast Medium Slow</p> <p>1/1000 sec 1/250 sec 1/30 sec</p>		Motion Blur Camera shake
Lose info Light	<p>ISO Sensitivity</p> <p>Low gain High gain</p> <p>ISO 100 ISO 6400</p>		Grainy Noisy

Side Effects	If you want your photo		Side Effects
	Darker	Brighter	
Deep depth of field Maybe lose overall sharpness	<p>Aperture</p> <p>f/8 f/5.6 f/4 f/2.8 f/2.0 f/1.4</p>		Shallow depth of field
Rolling shutter artifacts	<p>Shutter Speed</p> <p>Fast Medium Slow</p> <p>1/1000 sec 1/250 sec 1/30 sec</p>		Motion blur
Maybe lose details in quantization	<p>ISO Sensitivity</p> <p>Low gain High gain</p> <p>ISO 100 ISO 6400</p>		Noise

Other implication of ISO: Noise



http://en.wikipedia.org/wiki/Image_noise#Low_and_high-ISO_noise_examples

\$\$\$\$ in camera buys less noise at high ISO

Autoexposure programs (AE)

Wide variety. Stay away if you can.

Semi-automatic programs are better.

Av = aperture priority. You choose the aperture, camera will choose shutter speed. ISO might be automatic too.

Tv = Time priority; you set the shutter speed and maybe ISO, camera AE will choose the aperture.

M = Manual (maybe). You choose both aperture and shutter speed. Meter will tell you if exposure is OK.



to set over/under exposure

Lighten image, overexpose compared to AE suggestion +++
Darken, underexpose compared to AE, ----

★ Does your camera have a +/- button?

Shutter speed: motion blur at slow speeds

Aperture: low depth of field at large aperture. Diffraction will reduce sharpness at small apertures

ISO: Noise at high ISO, details maybe lost at low ISO

Deliberate under/over: Camera will change one or more of the other three settings, with attendant side effects. With underexposures, get loss of detail in shadows. Worse, at high overexposure, lose detail in highlights.

Last topic in photography: Resolution - Temporal and Spatial. Will come back after Clouds