Exposure and Camera Care

What makes a digital image?

A digital image is a mosaic of picture elements called **“PIXELS”**

Most digital cameras make square pixels. Fuji digital cameras make hexagonal pixels.

On standard cameras, one pixel is one color. Sigma cameras use a special proprietary sensor that allows pixels to be combinations of multiple colors.

Pixel color is measured in bit depth. The greater the bit depth, the smoother color transitions can be.

The range of colors a given system is capable of producing or representing is called **“GAMUT”**

8 bit color means that there are 2^8 (2x2x2x2x2x2x2x2=256) steps of color per channel. Making over 16 million possible colors (256^3).

The steps within an 8 bit gamut are measured from 0 (Black) to 255 (White).

16 bit color means that there are 2^{16} (2x2x2x2x2x2x2x2x2x2x2x2x2x2x2x2=65,536) steps of color per channel. Giving us over 281 trillion possible colors ($65{,}536^3$).

The steps within a 16 bit gamut are measured (in approximation) from 0 to 255 just like 8 bit; because our monitors can’t reproduce those colors and, even if they could, our eyes couldn’t tell the difference anyway.

A pixel whose color is represented with a number outside of that range is considered “out of gamut” and can not be correctly represented on a monitor or by most printers.

The reason 16 bit color is preferable to 8 bit is that when editing an image in 16 bit color, subtle color transitions can occur smoothly dramatically reducing an effect called “banding.”

JPEG format is only capable of supporting 8 bit color. This is yet another reason to shoot RAW files.

Sensors

There are currently two sensor technologies in use in digital cameras: CCD and CMOS.

Each has its own advantages and drawbacks.

CCD

Invented in 1969 by Willard Boyle and George E. Smith at AT&T Bell Labs.

Charge Coupled Device: A CCD is an analog device. When light strikes the chip it is held as a small electrical charge in each photo sensor. The charges are converted to voltage one pixel at a time as they are read from the chip. Additional circuitry in the camera converts the voltage into digital information.

1. Cheapest image sensor
2. Easiest to make

CMOS

Complimentary Metal-Oxide Semi-Conductor: Invented in 1963, patented in 1967 by Frank Wanlass, and designed and built by him while he worked for Fairchild Semiconductor in Ohio; a CMOS chip is a type of active pixel sensor made using the CMOS semiconductor process. Extra circuitry next to each photo sensor converts the light energy to voltage. Additional circuitry on the chip converts the voltage to digital data.

1. Eight times Faster than CCD
2. Uses fewer components than a CCD
3. Uses less energy than a CCD

Sensor Types

Each pixel is represented on your camera's sensor as a **"PHOTOSITE"** Each photosite has a tiny lens in front of it designed to direct light to the photosite as efficiently as possible. The photosites on a sensor are referred to casually as "pixels."

A million pixels is referred to as a "megapixel."

A sensor's resolution is represented by a two-dimensional count of pixels or photosites.

A Nikon D7000 has a resolution of 4,928 x 3,264,

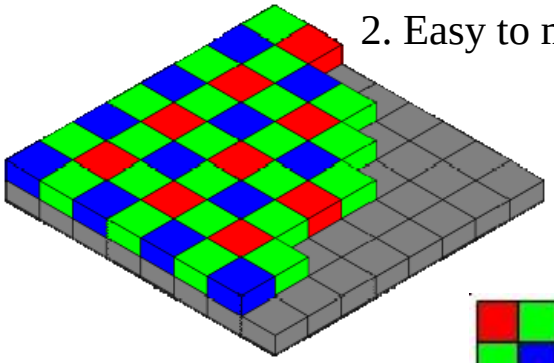
or 16.2 megapixels.

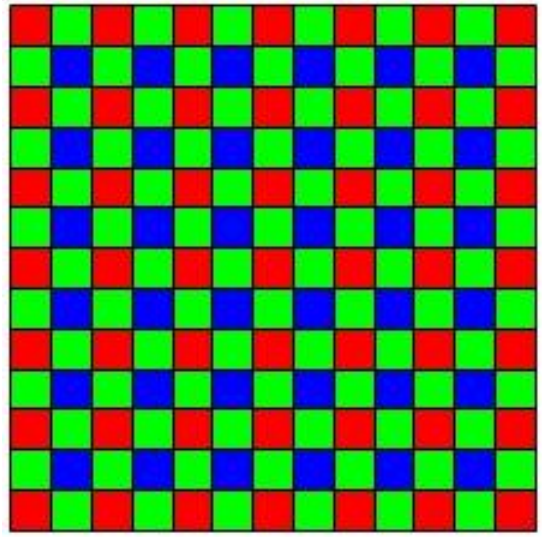
How the photosites are arranged on a sensor determines the type of sensor your camera uses.

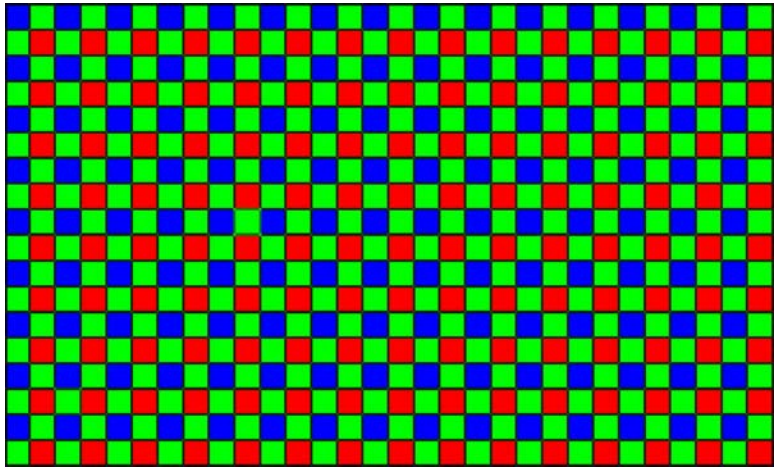
Bayer Filter

A Bayer filter mosaic is a color filter array (CFA) for arranging RGB color filters on a square grid of photo sensors. Its particular arrangement of color filters is used in most single-chip digital image sensors used in digital cameras, camcorders, and scanners to create a color image. The filter pattern is 50% green, 25% red and 25% blue, hence is also called GRGB or other permutation such as RGGB. It is named after its inventor, Dr. Bryce E. Bayer of Eastman Kodak.

1. Not as color accurate as a Foveon Sensor, but still very close to the human eye.
2. Easy to make-miniaturizes well



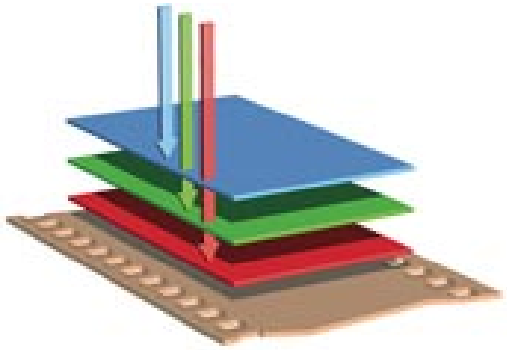




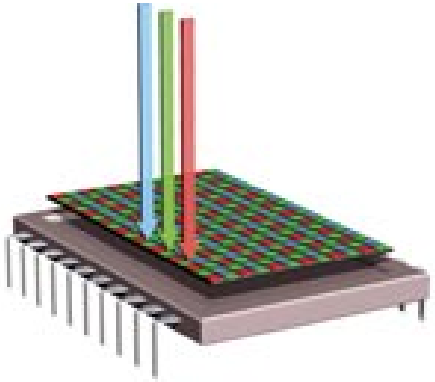
Foveon

The Foveon X3 sensor is a CMOS image sensor for digital cameras, designed by Foveon, Inc. and manufactured by National Semiconductor and Dongbu Electronics. It uses an array of photosites, each of which consists of three vertically stacked photodiodes, that are organized in a two-dimensional grid. Each of the three stacked photodiodes responds to different wavelengths of light, i.e., each has a different spectral sensitivity curve. This is due to that fact that different wavelengths of light penetrate silicon to different depths. The signals from the three photodiodes are then processed, resulting in data that provides the three additive primary colors, red, green, and blue.

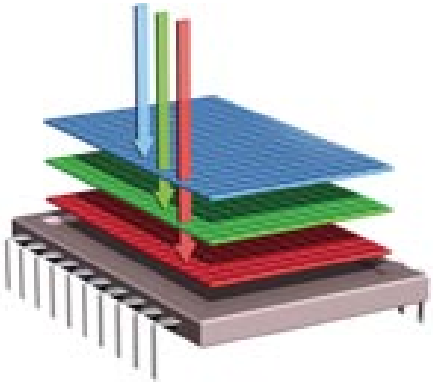
1. More accurate color than CCD or regular CMOS
2. Slower processing than regular CMOS, because there is approximately three times as much to process



COLOR FILM contains three layers of emulsion which directly record red, green, and blue light.



TYPICAL DIGITAL SENSORS have just one layer of pixels and capture only part of the color.



FOVEON X3 direct image sensors have three layers of pixels which directly capture all of the color.

How we measure light…

The term used to describe how light, or exposure, is measured is “stop.”

An increase of one stop doubles the exposure, a decrease of one stop halves the exposure.

What your meter thinks…

The starting point for metering is often referred to as the “Sunny 16” or the “Sweet 16” rule. It was the basis for most exposures before meters were built into cameras.

Sunny 16

On a bright sunny day

at f/16,

your shutter speed should equal

your ISO.

On a bright, sunny day, if you shoot at ISO 100, then your shutter speed should be 1/100 second or pretty close to that with your aperture set to f/16. So if you open up to f/11 your shutter speed should be 1/200 second and at f/8, 1/400 second. Using **"Reciprocal Exposures"** you can make a fairly accurate guess as to what your meter will want you to choose for your exposure setting.

Reciprocal Exposure

Aperture->	f/22	f/16	f/11	f/8	f/5.6	f/4
ISO						
100	1/50	**1/100**	1/200	1/400	1/800	1/1600
200	1/100	1/200	1/400	1/800	1/1600	1/3200
400	1/200	1/400	1/800	1/1600	1/3200	1/6400
800	1/400	1/800	1/1600	1/3200	1/6400	1/12,800

A reciprocal exposure chart can be made for any starting exposure combination. This allows you to see that for every exposure you choose, there are plenty of alternatives depending on how you want the picture rendered. You have control over motion-stopping and depth of field and can manage them through use of different ISO, shutter speed, and aperture combinations.

The Sunny 16 Rule even works when photographing the moon. The moon is a bright object surrounded by darkness. If your main interest is the moon, you can set your exposure based on the Sunny 16 rule to make everything around it black, while getting the moon correctly exposed.

It’s always noon on the moon…

ISO 200, 1/200 second, f/16

Shutter Speed and Aperture…

Shutter speed is the length of time of an exposure and is measured in “stops.”

Aperture, lens opening, and f-stop all refer to the size of the opening through which light passes within the lens. This controls the amount of light that passes through the lens while the shutter is open. This is also measured in “stops.”

Shutter types

Most modern cameras utilize vertical travel focal plane shutters. This allows for faster shutter speeds even at wide apertures and less complex shutters. Modern DSLR's have focal plane shutters.

Some point-n-shoot and specialty cameras utilize lens shutters. This allows the camera to be smaller, lighter and quieter. It also allows for the flash to synch up at any shutter speed.

Focal Plane Shutter

A modern DSLR uses a Vertical Travel Focal Plane Shutter. A Horizontal Travel Focal Plane Shutter was common on older film SLR's but, since a vertical travel shutter has a shorter distance to travel: faster shutter speeds and faster Flash Synch speeds can be achieved as well as a longer shutter life.

While the term "shutter" brings to mind a vision of storm shutters on a window that swing open and closed, a camera shutter works nothing like that. A focal plane shutter is two curtains, one directly in front of the sensor, the other is folded above the sensor and unfurls to cover it as the first curtain reveals part of it.

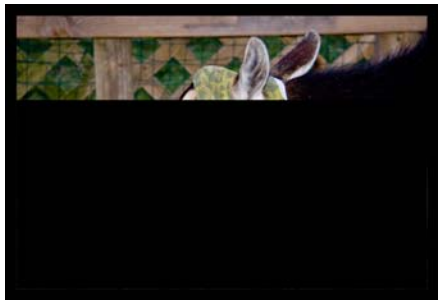
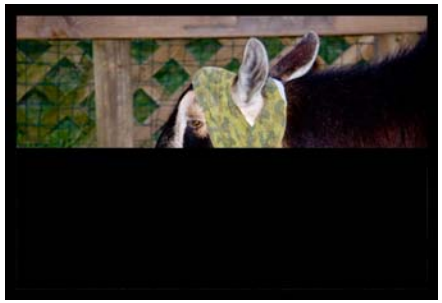
The action of a focal plane shutter appears as a slit that travels downward in front of the sensor revealing a small portion of the sensor at a time to light.

When you press the shutter button on a camera all the way, it sets a series of events into motion, each linked to the other; hence the term "REFLEX."

When you push your shutter button…

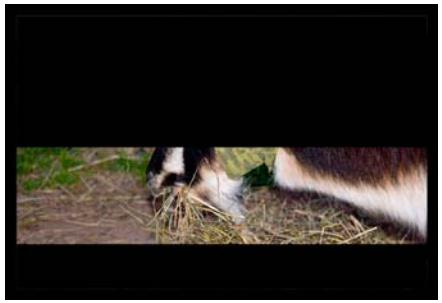
1. If you are using auto focus, the lens focuses (with manual focus, you would have already done this)
2. If you are using Auto Exposure, the camera sets the exposure (with manual exposure, you would have already done this)
3. Once focus and exposure have been achieved, the mirror begins to swing upward to allow light to pass through to the focal plane. When the mirror is in the full up position, it blocks the viewfinder which is why the viewfinder goes blank for a moment during exposure.
4. As the mirror is swinging up, the controls in the camera (either mechanical or electronic) begin to stop down the aperture.
5. Once the mirror is completely out of the way and the aperture is fully set, the FIRST CURTAIN begins to travel downward.
6. When the FIRST CURTAIN has reached a certain point, depending on shutter speed, the second curtain begins to travel down behind it.

Vertical Travel Shutter


First Curtain pulls down…

Second Curtain follows…




First Curtain finishes travel…

Second Curtain finishes and closes.

More Reflex Action…

7. When the second curtain has finished its travel, the mirror begins to fall back down into position…

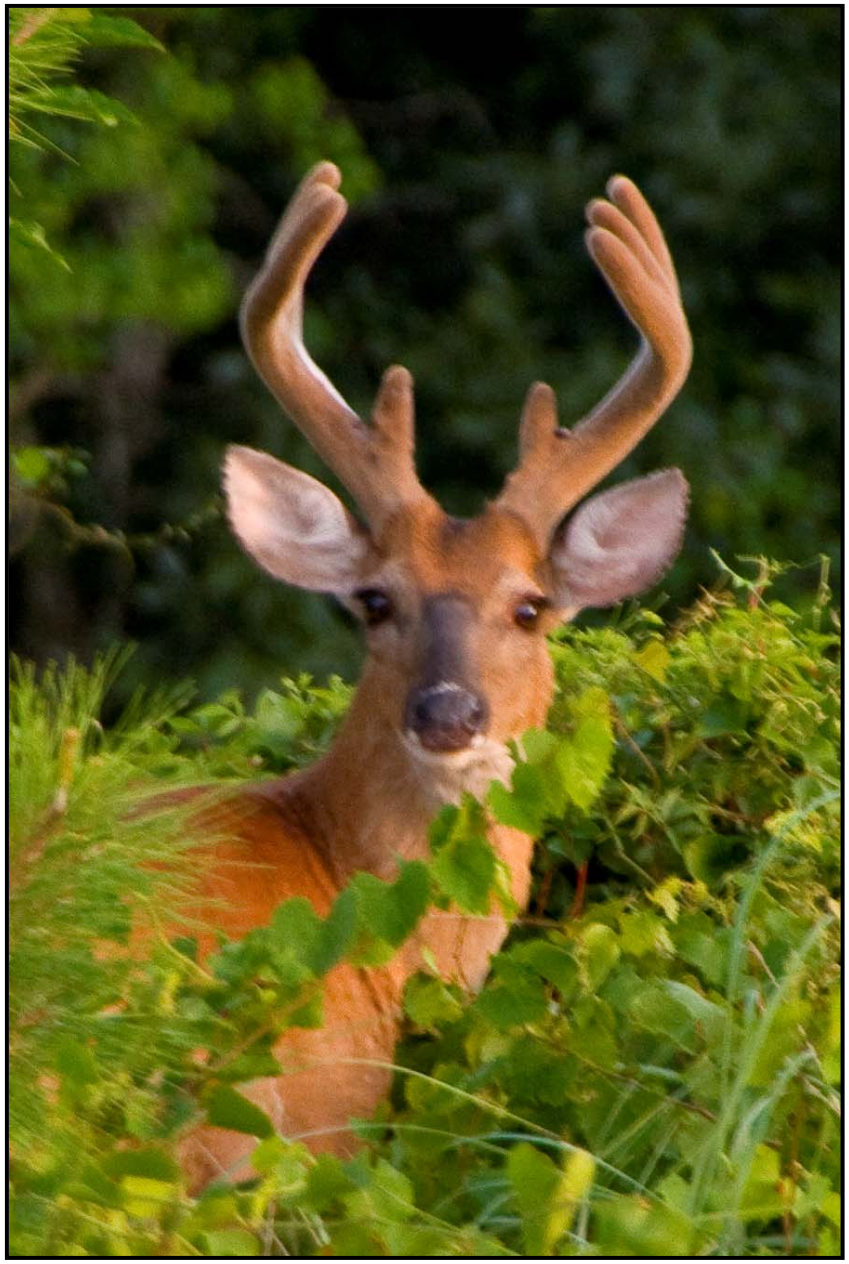
8. and the aperture control releases and allows the aperture in the lens to reopen to full

9. Both the front and rear curtains are pulled back up into the beginning position, thus resetting, or cocking, the shutter.

10. Now the camera is ready to take the next picture, all in the blink of an eye.

Shutter Speed’s Job

1. Affect exposure by controlling how long the sensor is exposed to light.
2. Control blur by eliminating (or minimizing) camera shake.
3. Stop subject motion by being too fast for motion to show.
4. Enhance motion blur by being slow enough for motion to show.



250mm Lens, 1/60th Second

Camera Shake

Camera could not be held steady enough to get a sharp image. A tripod may have helped.

Shutter Speed Rule of Thumb:

Shutter speed number should be equal to or greater than lens focal length; or use a steadying device like a tripod or a bean bag.

Camera Shake, fixed…

250mm Lens, 1/80th Second

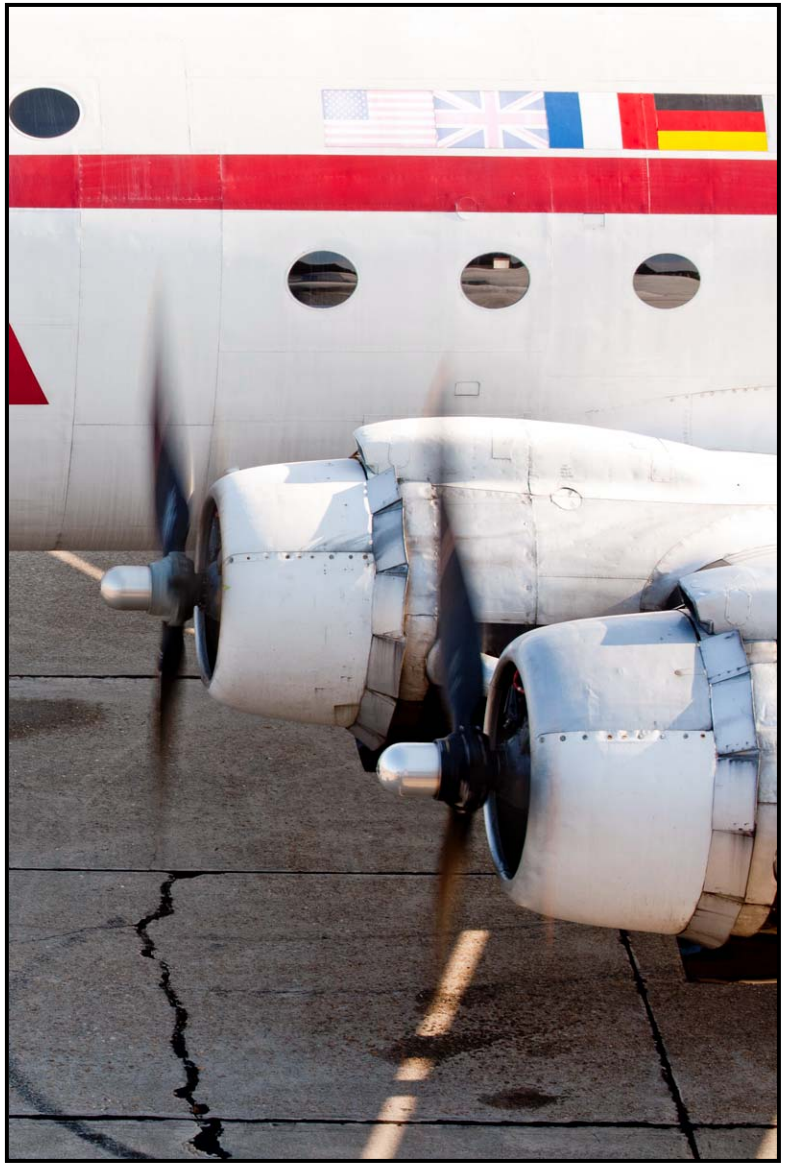
…on a fence post,

holding my breath.

Allow Motion Blur

2
Seconds
at
f/5.6
ISO 160

Almost Stop Motion



ISO 100

1/60 Second

f/8

Completely Stop Motion

ISO 200

1/250 second

f/5.6

The Aperture's Job

1. Affect exposure by controlling the amount of light that strikes the sensor while the shutter is open.

2. Increase depth of field for scenic pictures or to include the background more clearly.

3. Decrease depth of field to isolate the subject.

Depth of Field

The portion of a scene that appears sharp in the image.

An image with broad depth of field will have more area before and/or after the subject that is sharp.

An image with narrow depth of field will have little or no area other than the subject that is sharp.

Factors That Affect DOF

1. Lens focal length: The longer the lens, the narrower the depth of field will seem.

2. Distance to the subject: The closer the lens is focused, the narrower the depth of field appears.

3. Sensor Size: The larger the sensor, the narrower the depth of field.

4. Aperture: The bigger the aperture, the narrower the depth of field.

Narrow Depth Of Field f/2.8

Wide Depth of Field f/11

The Aperture Number is a Ratio

Why in the world is f/2.8 bigger than f/11?

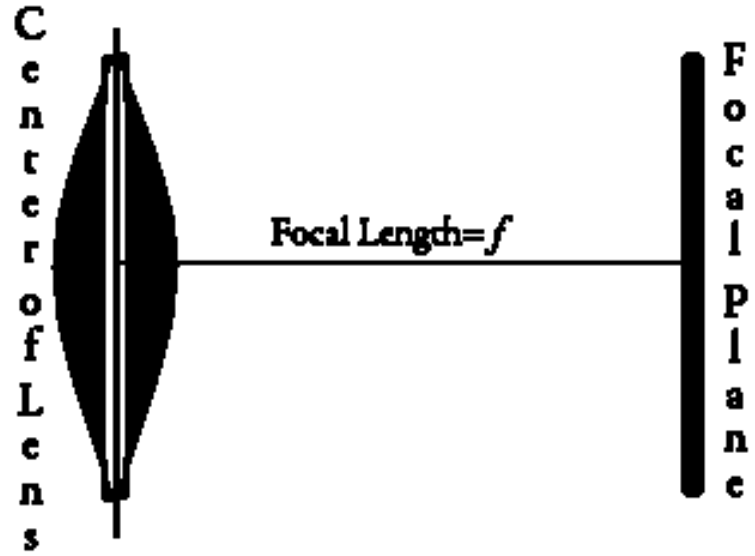
For the same reason that 1/3 is bigger than 1/11:

the aperture is represented as a fraction or a ratio. The aperture actually means the ratio of the focal length of the lens to the size of the aperture; “f” meaning “focal length.”

Focal Length and Aperture

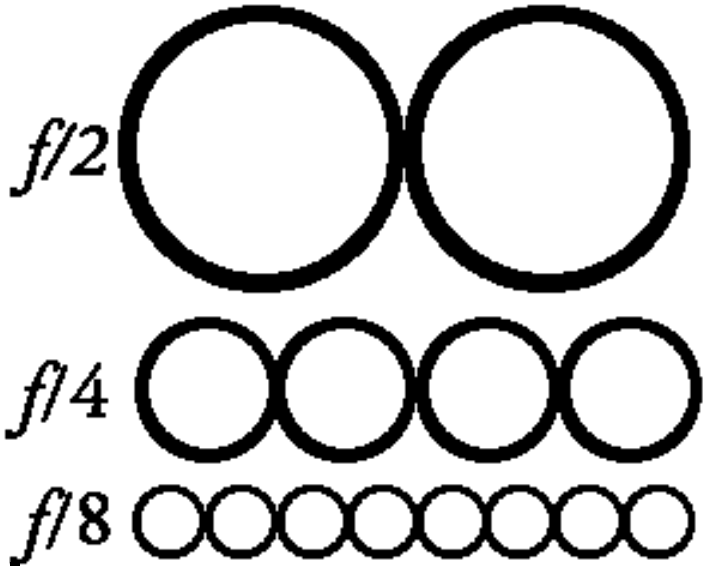
FOCAL LENGTH

The distance between the film (or image sensor) and the optical center of the lens when the lens is focused on infinity.



Aperture or Lens Opening

The size of the aperture is expressed in “f/numbers” representing the ratio of the lens focal length to the size of the opening. This is why the higher the f/number, the smaller the lens opening.



Over and Under Exposure

Over exposure and under exposure are arbitrary and sometimes, misleading terms. To say that an image is “over exposed” is to say that it received too much light for the correct exposure; so an under exposed image didn’t receive enough light. Sometimes a photographer may choose to over or under expose all or part of an image either to achieve an affect or because there is no choice but to give in to the laws of physics. In the photograph of the moon, (next frame) the moon was correctly exposed because it was the subject of the picture. The empty sky was severely under exposed, which added to the quality of the image rather than detracted. It would have been nearly impossible to correctly expose both the moon and the indigo sky without multiple exposures and a lot of post-processing.

Over and Under Exposure

In the picture of the woodworker's shop that follows, the bright sunlight coming through the windows in the back wall was way over exposed in order to correctly expose the lighter area inside the room. The room is the subject, and the view out of the windows was of a plain brick wall; so the windows were allowed to go overly bright. The light walls of the room reflected light in nearly every direction, thus mitigating the need for a flash, allowing for very soft shadows, and eliminating the un-charming view out the windows.

Correct and Incorrect Exposure

The only time a picture should be called under or over exposed is when the photographer accidentally got the exposure wrong; so over or under exposure is not necessarily always bad.

When working with uniform or diffuse light the need to choose what aspect of the picture will be correctly exposed is usually somewhat lessened. Softer light is generally preferred because it tends to render better color saturation, softer shadows, and lower contrast.

The following series of five shots, taken in fairly uniform light, are examples of correct, over, and under exposures.

First, the correct exposure…

Correct Exposure ISO 640, 1/80 sec, f/5.6

The next shot shows what happens with the shutter speed slowed down just one stop…

Over One Stop ISO 640, 1/40 sec, f/5.6

…then with the shutter speed still too slow and the aperture opened one stop…

Over Two Stops ISO 640, 1/40 sec, f/4

Now, we'll go the other way. The original, correct exposure was ISO 640, 1/80 second shutter speed and an aperture of f/5.6. This time the ISO was reduced one stop…

Under One Stop ISO 320, 1/80 sec, f/5.6

Then, bump the shutter speed up one stop…

Under Two Stops ISO 320, 1/160 sec, f/5.6

Over 1

Over 2

Under 1

Under 2

Correct

Your Camera's Meter…

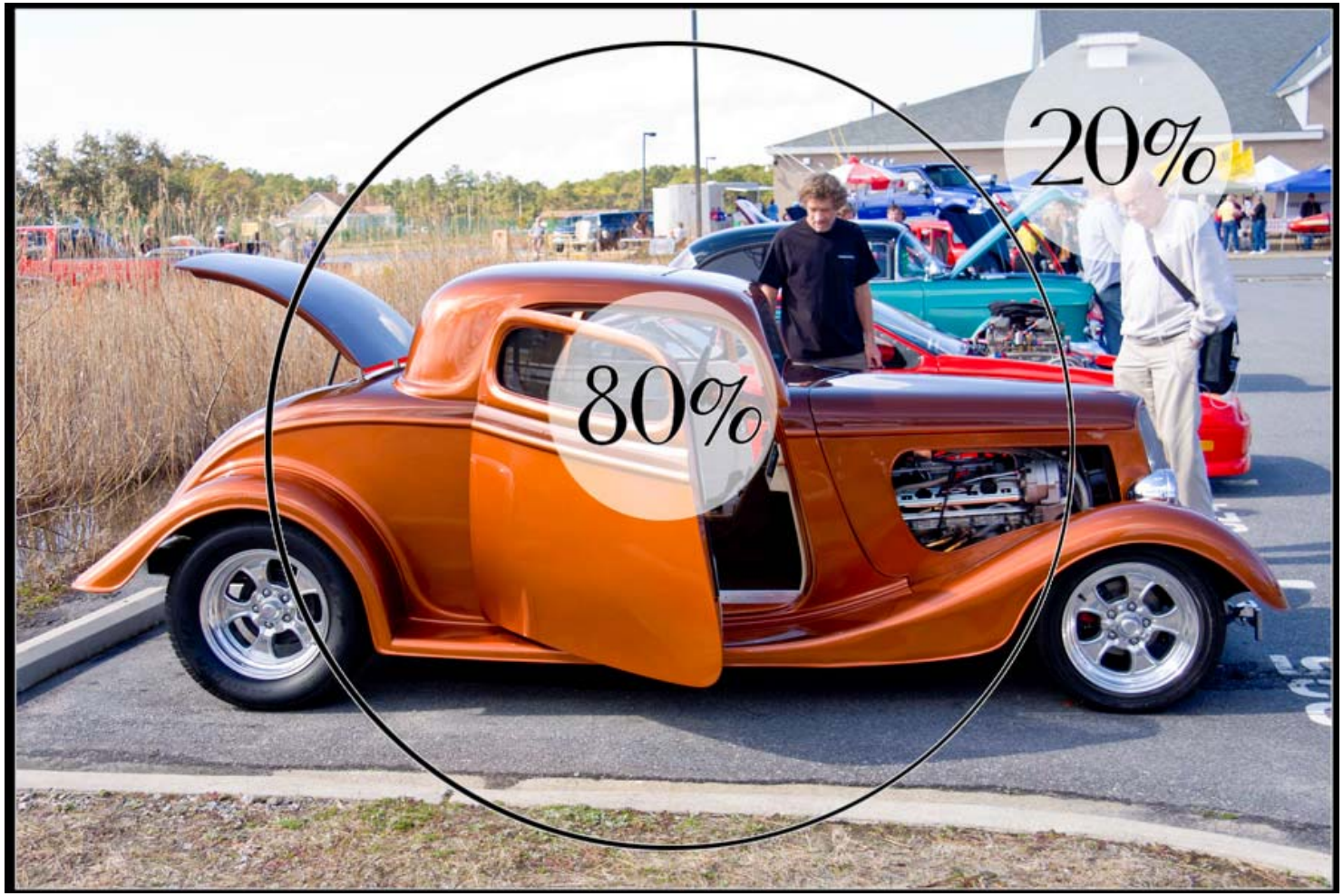
There are four general meter type categories:

1. **Center-weighted**
2. **Partial, Small Center, or Large Spot**
3. **Spot**
4. **Multi-Segment, Matrix, or Averaging**

Each has a different metering "pattern," and each is more suited to certain situations.

Center-Weighted Metering

Biases metering to center of frame. Good for shooting situations with the subject centered and background lighting is less important.

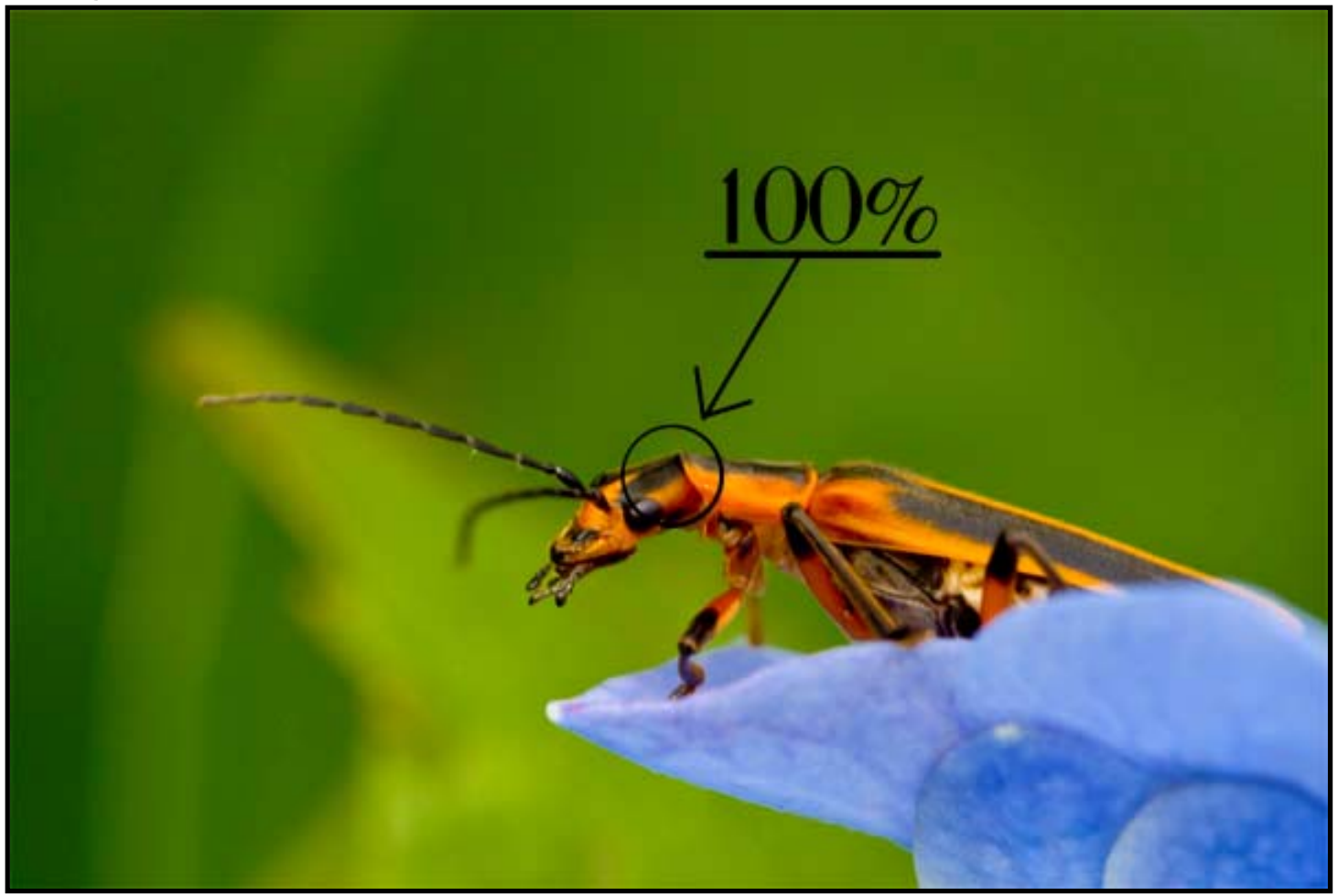


Partial Metering

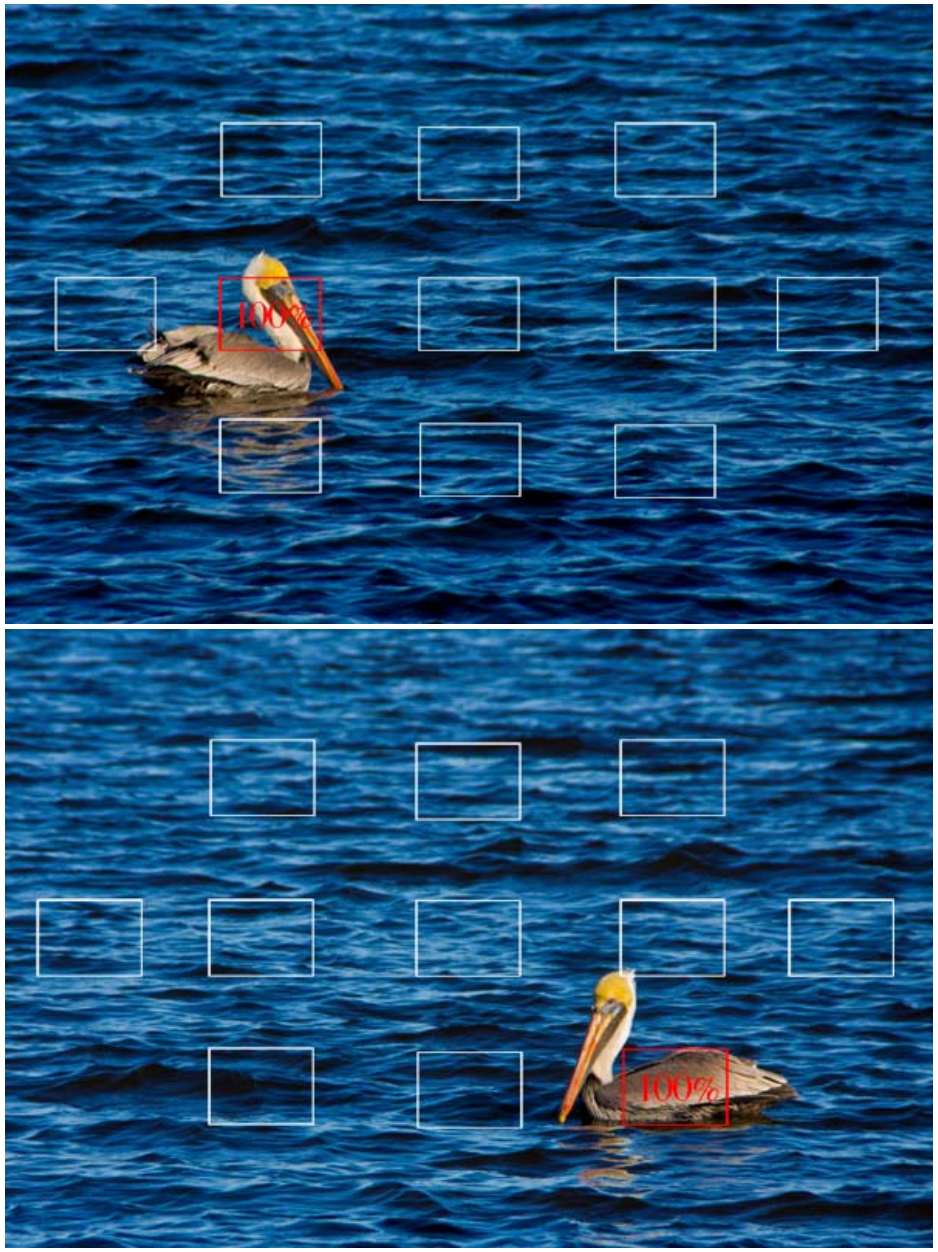
Meters entirely off center of frame. Good for spot-lit or back-lit subjects that dominate the center of the frame.

Spot Metering

Meters only off of a small spot in the center of the frame. Good for smaller spot-lit or back-lit subjects or for when lighting is tricky and you want to calculate your exposure yourself. Works best in Manual Exposure Mode.



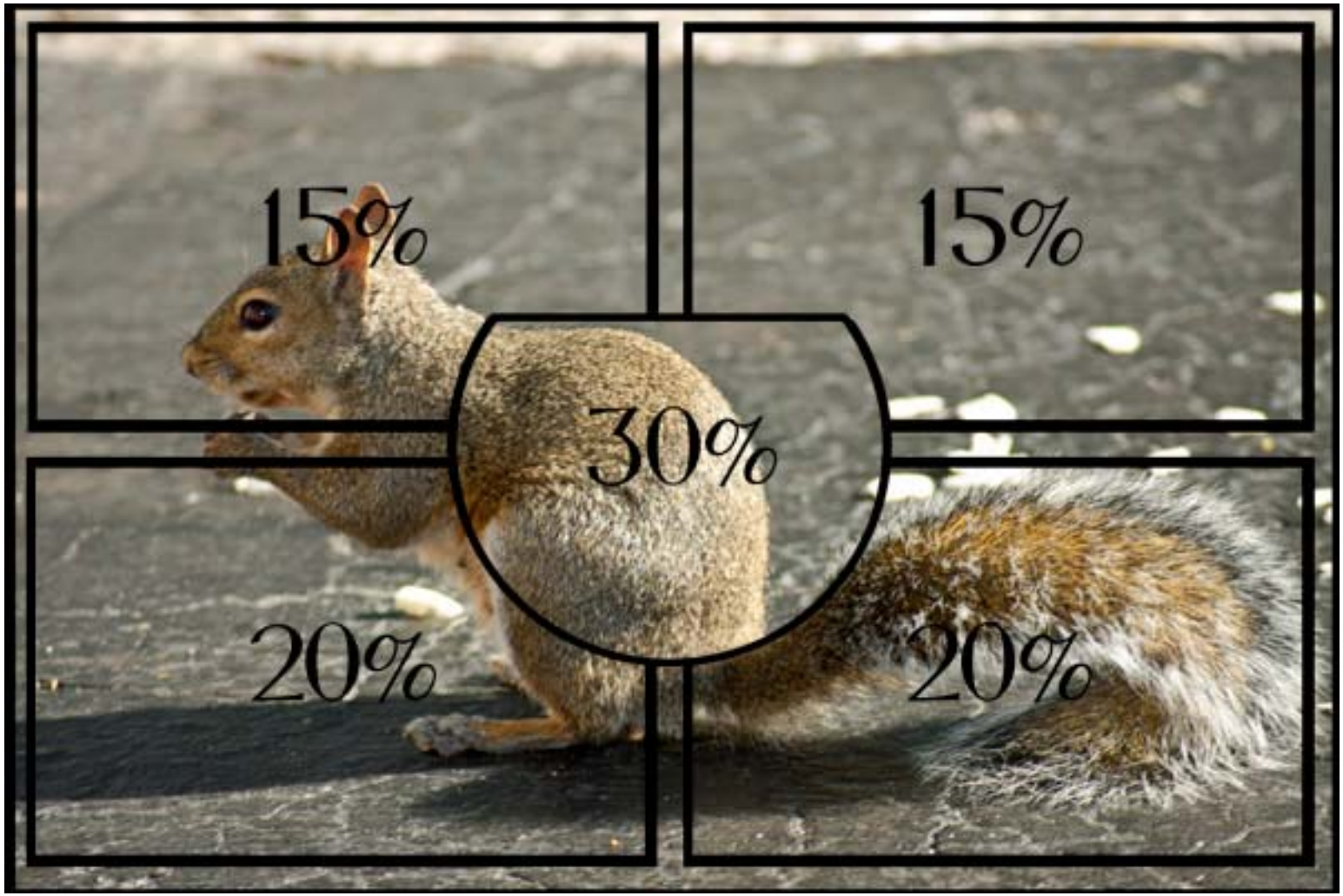
Spot Metering



A useful trick with spot metering, is that most newer cameras link the spot meter to the focusing point. If you have selected a focusing point in your viewfinder that is off-center, your camera will probably meter from that point instead of the center. Some cameras do this by default, some cameras require that the function be turned on. Consult your camera's owner's manual.

Multi-Segment, Averaging or Matrix Metering

Divides the frame into several parts and calculates exposure based on each segment's, or cell's reading. Good for most shooting situations. Best choice if using Programmed Auto.



If the subject ain’t 18% gray…

Your exposure meter wants the world to be a nice un-intimidating tone of medium gray.

This will cause dark subjects to be lighter than they should;

and bright subjects to be darker than they should.

When shooting a bright subject that you want rendered at the correct level of brightness, you must increase exposure.

When shooting a dark subject that you want rendered at the correct level of brightness (or darkness), you must decrease exposure.

Bright Background

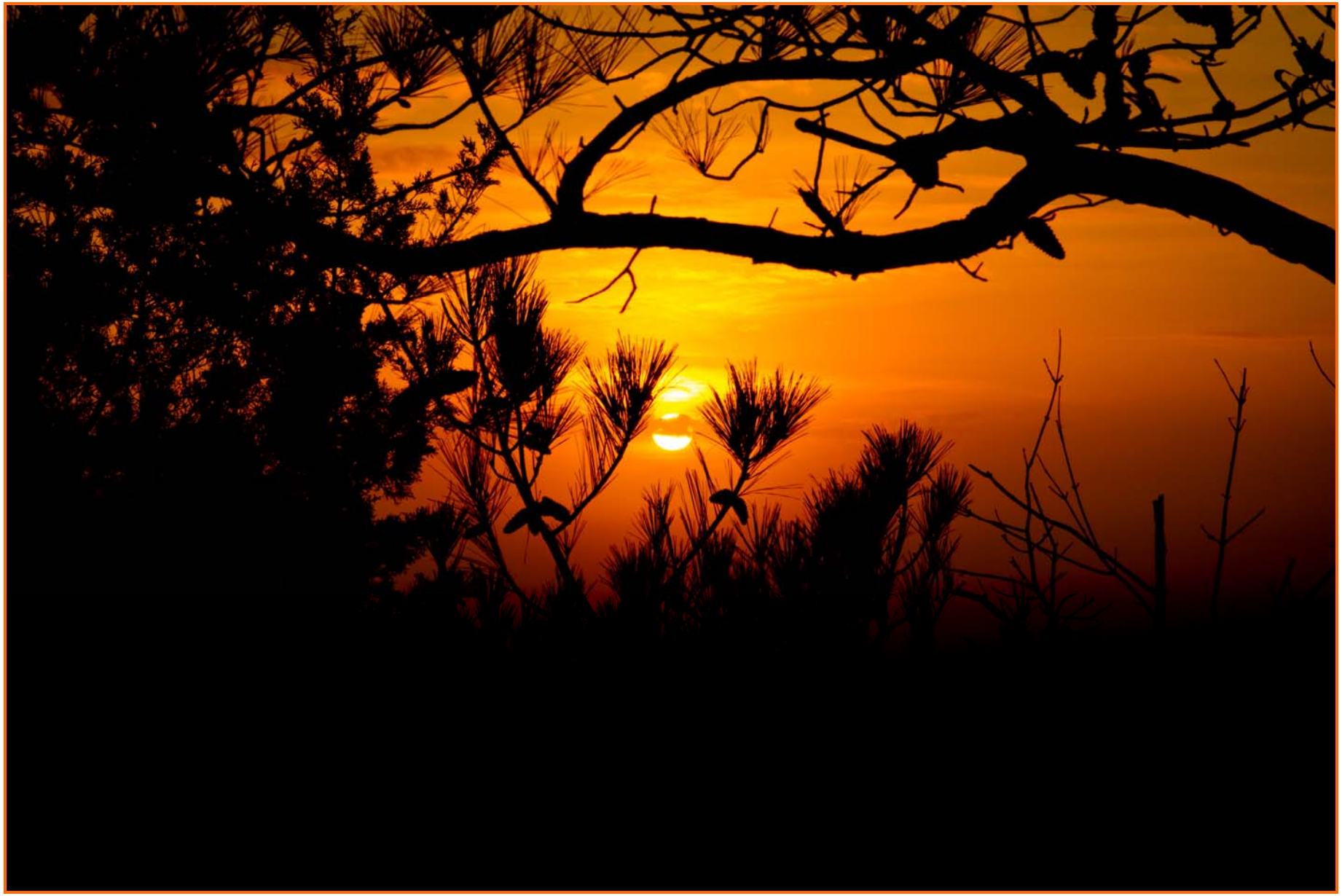
Bright Background
Exposed for Shadows

Dark Image Agreeing with Meter

Dark Image Exposed to be dark

Sunrise, according to the meter…

Sunrise by metering mid-tones…



Auto Exposure Modes

Programmed Automatic:
Sets both Shutter Speed and Aperture based on a reading taken by the camera's meter. Represented on the Mode Dial by "P."

Can be overridden by setting Exposure Compensation;
or, on some cameras rotating a control dial changes settings to a reciprocal exposure.

Quick and easy, minimizes control by the photographer.

Auto Exposure Modes

Shutter Priority Automatic:
When you choose a shutter speed, the camera sets the Aperture based on a reading taken by the camera's meter.
Represented on the Nikon Mode Dial by "S."
Canon and Pentax use "Tv" for Time Value.

Can be overridden by setting Exposure Compensation;
or, on some cameras rotating a control dial sets exposure independently of the meter.

Allows motion-stopping/blurring control by the photographer, while maintaining auto exposure.

Auto Exposure Modes

Aperture Priority Automatic:
When you choose an aperture, the camera sets the Shutter Speed based on a reading taken by the camera's meter.
Represented on the Nikon Mode Dial by "A,"
Canon and Pentax use "Av" for Aperture Value.

Can be overridden by setting Exposure Compensation;
or, on some cameras rotating a control dial sets exposure independently of the meter.

Allows Depth-of-Field control by the photographer,
while maintaining auto exposure.

Auto Exposure Modes

Auto ISO:

Not always a shooting mode, but a “setting.”
Varies from camera to camera.

Canon:
Sets ISO automatically between 100-800 in P, Tv, and Av.
When using flash or manual exposure, sets the ISO to 400.

Nikon & Pentax:
Sets ISO automatically to best for whatever mode
and exposure settings are in use.

Pentax also offers a “Sensitivity Priority” mode that sets both Aperture and Shutter Speed based on the chosen ISO.

Manual Exposure Mode

Allows setting of both Shutter Speed and Aperture by the photographer. A bar graph style representation of the meter tells when exposure is over, under or correct.

This gives the photographer complete control of exposure, but can be slow in a rapidly changing lighting situation.

Requires a bit of practice.

Camera Care External

1. **Cleaning all non-optical exterior surfaces**

    a. Any soft cloth or tissue

    b. No water, if moisture is needed, lens cleaner or alcohol on a cotton swab.

2. **Exterior Optics**

    a. 100% cotton cloth

    b. Lens tissue made for coated optics

    c. Never wipe a dry lens! Never use water, fog it with hot breath.

    d. For persistent problems, use lens cleaning fluid.

    e. Never apply liquid to the lens, apply it to the cloth or tissue

Camera Care Internal

1. Focusing screens on SLR's

a. No touchy!!! Very delicate!!!

b. Very careful application of blower brush

c. Dust on the focusing screen will not affect exposure or image quality.

2. SLR Mirror

a. No touchy!!! Very delicate!!!

b. Dust on the mirror will not affect exposure or image quality.

c. Have problem spots professionally cleaned if you can't live with them. Mirrors can cost hundreds of dollars to replace.

d. Wrecked mirrors are not covered by warranty.

Your Sensitive Sensor

SLR Image Sensor

a. No touchy!!! Very delicate!!!

b. Consult your owner's manual for procedure

c. Use only a quality cleaning kit

d. A damaged image sensor can completely disable a camera. With most cameras, replacing the image sensor costs only a little less than a new camera.

e. Wrecked sensors are not covered by warranty.

Camera Cleaning Supplies

Good Lens Tissue: www.adorama.com, Search “Lens Tissue”

Zeiss Pre-Moistened is good for persistent problems.

Adorama Brand tissue is great for everyday use.

Better Lens Tissue: www.cleanoptics.com, Scroll down to “Premium Optical Tissue. That’s my favorite for almost twenty years.

“Formula MC” is my favorite lens cleaning fluid.

I avoid cleaning cloths because they can hold dust and grit for later.

Sensor Cleaning

www.photographicsolutions.com

1. Click on “Swab Sizes”
2. Find your camera and note the appropriate swab size
3. Go to www.adorama.com
4. Search for “Photographic Solutions”
5. Find what you chose.
6. Buy it.
7. Follow the sensor cleaning instructions for your camera to prepare your camera for a cleaning.
8. Follow the instructions for the swabs and fluid.

General Precautions

1. Do not expose to moisture.
2. Do not expose to extreme temperatures, especially heat.
3. Protect from impact, use the strap.
4. Do not change SLR lenses in a hazardous environment.
5. Do not change batteries or storage media in a hazardous environment.
6. Keep in a case or gadget bag when not in use.
7. Camera armor for SLR’s is good (www.cameraarmor.com)
8. Protective shields for LCD panels are good.
9. Cameras don’t belong in the trunk of your car.
10. Do not leave in plain sight in your car.

Batteries

1. Never store batteries in any device for more than a week.
2. Lithium/Ion batteries, Nickel-Metal/hydride batteries and lead/acid batteries should be charged as soon as you're through with them. Keeping them topped off makes then last through more charge-discharge cycles.
3. Try to avoid running re-chargeable batteries completely dead, unless they're in-cads, which are rare these days.
4. Care for your batteries as you would for your camera.
5. Always have plenty of back-up batteries ready to go.
6. Avoid aftermarket rechargeables.
7. Never dispose of batteries in a fire
8. Don't try to open them!

Storage Media

1. Care for your storage media as you would for your camera.
2. Do not expose to magnetic fields.
3. Reformatting is not necessary with every use, but it doesn't hurt to do it every couple of months.
4. Copy your images to your hard drive as soon as you can.
5. Do not delete your images from your card until you have written a CD or DVD and checked it to make sure it works.
6. You can never have too many back-up copies.
7. Store back-up duplicates in different locations.
8. Replace flash cards every year or so.

Exposure Exercises

Pictures in open shade using various metering techniques and exposure modes.

Start either in early morning or late evening, but not in the dark. Do not use flash.

1. Programmed Automatic

2. Aperture Priority using at least three different lens openings.

3. Shutter Priority using at least three different shutter speeds.

4. Manual Mode

A. Take a general meter reading of the whole scene, and expose according to the meter.

B. Take a close-up meter reading of your subject, set your exposure. Return to where you want to take your picture, and shoot.

C. Take a meter reading of the background, Set your exposure, shoot.

5. If you have questions, call or email me.

Exposure Exercises

Shoot all JPEGS for this exercise.

A. In bright Sunlight…

1. In any Automatic Mode, with no exposure compensation, take a picture of a plain white wall or similar subject so that it completely fills the frame, composition does not matter, this won't be art. Make a note of the exposure your camera uses.

2. In Manual Exposure Mode, starting with the exposure setting from the first picture in this exercise, shoot seven or eight pictures, each with the shutter speed set one notch slower, or the aperture set one notch bigger (lower numbers).

3. View the images on your computer, and note which is actually white, but still has some detail.

B. In morning or evening light or light shade…

1. In any Automatic Mode, with no exposure compensation, take a picture of a plain black (or very dark colored) wall or similar subject so that it completely fills the frame, composition does not matter, this is still not art. Make a note of the exposure your camera uses.

2. In Manual Exposure Mode, starting with the exposure setting from the first picture in this exercise, shoot seven or eight pictures, each with the shutter speed set one notch faster, or the aperture set one notch smaller (higher numbers).

3. View the images on your computer, and note which is actually black (or very dark), but still has some detail.