Camera Basics

At its simplest, a camera is a light-tight box with an opening at one end to admit light and a light sensitive medium at the opposite end to record the image of the light. A lens is usually used to control the light so that it can be focused on the sensitive medium, but there are variations that include a simple pinhole or multiple lenses. The lens is often combined with a diaphragm or aperture that is used to control the amount of light that is focused on the medium, and a shutter is used to control the length of time that the medium is exposed to the light. Because most cameras share lens aperture, shutter, and sensitive medium, we'll start by talking about these common characteristics. Here we'll try to cover them in an abstract way so that you'll be open to the commonalities that all cameras have, not just the differences between say, film and digital cameras.

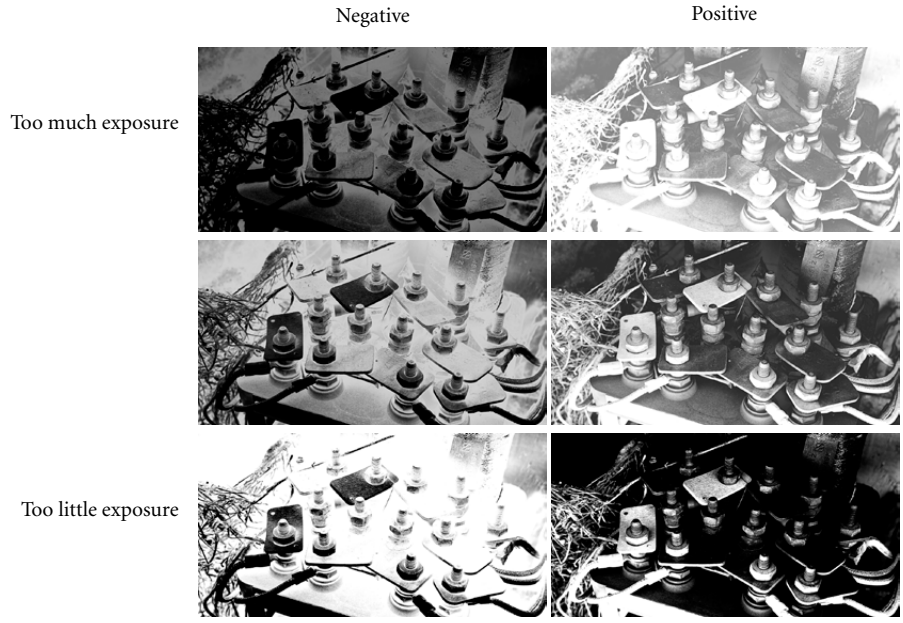
Sensitive Medium

A camera's light sensitive medium can be film or digital, color or monochromatic; it can be flat or in some special cases, curved. When we say the medium is "sensitive" we mean that it reacts to light in a way that is *proportional* to the amount of light it is exposed to. Negative film responds with latent chemical changes that cause it to have more *density* (or become darker) with more exposure to light when it is developed. Digital media respond to light by creating voltage in proportion to the amount of light that falls on it. That voltage is converted to a value that is stored for each picture element (pixel) and the resulting array can then be reproduced as an image.

In either case there is a *threshold* of light needed to cause any response on the medium, and there is also an upper limit beyond which no further response is possible. The range between these two limits is the medium's dynamic or density range. All of an image's possible values must be expressed within this range or else the values will be *clipped*. Values brighter than the brightest values a medium can record are said to *block up*. Values that are darker than the blackest black appear as *empty shadows*.

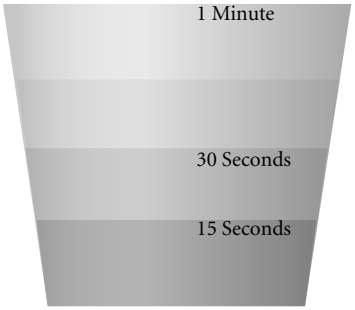
A medium's sensitivity to light can be measured, and is known as the medium's speed—faster films or sensors require less light to produce a given effect than slow films or sensors. The measurement of this speed is the film's ISO rating. A film rated with an ISO speed of 100 requires twice the amount of light to produce a given density as a film rated at 200.

The goal then is to control the amount of light so that the brightness range of the image fits within the density range of the medium.



Filling the Bucket

To understand how you control this exposure it will help to think of sensitivity as the absolute amount of light needed to get a correct exposure, and to think of that amount as a volume of water. For example, think of the appropriate exposure for a film with an ISO of 100 as a "one gallon bucket" of water. An exposure for an ISO of 50 requires a two gallon bucket; for ISO 400 you'll only need a quart.



To fill the bucket with water, you'll need a flow at a certain rate times a length of time. For example, if you have a one gallon bucket, a hose that provides one gallon per minute of flow, you will fill the bucket in one minute. You could also increase the flow to two gallons per minute and reduce the time to 30 seconds; or you could reduce the flow to a quart per minute and increase the time to four minutes.

Note that in each case, when you change one part of the equation the other part changes in a reciprocal manner. One half the flow requires twice the time. Four times the time requires one quarter the flow.

Controlling Exposure

On a camera you control the flow with the lens aperture and you control the length of time the light flows onto the medium with the shutter. There are several kinds of shutters, each with their own peculiar features. What's important now is that you start to imagine what is happening to light when you operate the camera's controls.

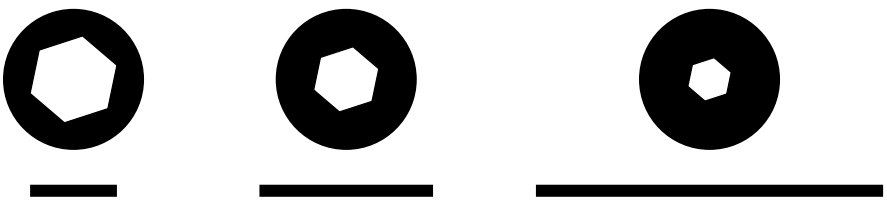
The shutter is marked in reciprocal parts of a second—60 on the shutter speed control stands for 1/60th of a second; 500 stands for 1/500th; 4 stands for a quarter of a second. Note that each marking is half or double the next.

The aperture seems more mysterious at first, but it is just as logical and makes both mathematical and practical sense. While the shutter measures time in a linear way, the aperture controls the *area* of the lens that light passes through when you adjust its diameter. The area changes in proportion to the square of the diameter. So, to double the area you must increase the diameter by the square root of 2, which is very close to 1.4. This gives the following progression when you start with a relative diameter of 1:

1 … 1.4 … 2 … 2.8 … 4 … 5.6 … 8 … 11 … 16 … 22 … 32 … 45 … 64

These markings are known as f numbers. Mathematically, they are the proportion of the focal length of the lens divided by the aperture's diameter. As with shutter speeds then, each marking is half or double the next. If you need twice as much light at f8, open the aperture to f5.6.

One goal of this course is to give you the experience of using these numbers until they become instinctive and you will know in your gut what to do when you are in a difficult or unusual lighting situation. As you will see, these controls have other functions, which you will need to balance between your vision and the practical reality of getting an image recorded.



f5.6 @ 1/125 = f8 @ 1/60 = f11 @ 1/30

Creative Decisions and Control

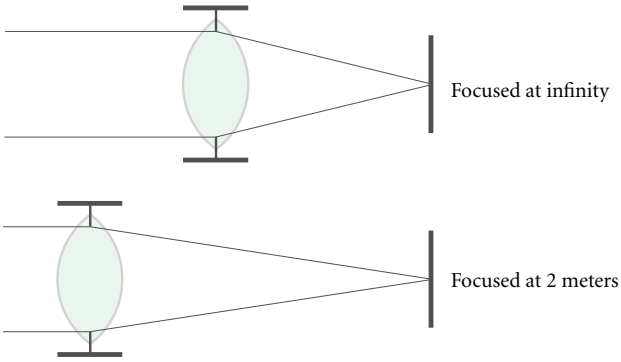
Much of the practice of photography involves the compromise between one set of priorities and another. So without any other criteria to guide your choice between one set of apertures and shutter speeds, these choices are equivalent, allowing the same amount of light to expose your image:

*f*5.6 @ 1/125s *f*8 @ 1/60s *f*11 @ 1/30s

In practice though, there are several reasons why one of these choices may be better than the others for the particular image you have in mind. When you start to juggle priorities, one of the first may be a consideration for depth of field.

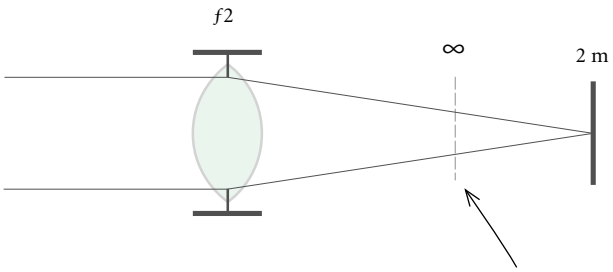
Depth of Field / Depth of Focus

First, notice what happens when you change the focus of your lens. When the focus is set for infinity (∞) it is as close to the film plane as it will go. Move the focus closer and the lens extends away from the camera body and film plane. Focus on a lens changes by changing the distance to the film plane. An image is focused when the light coming from each subject point is bent as it passes through the lens so that all light from that point meets at a single point on the film plane. At infinity the focal distance is the focal length of the lens. By the time the lens extends twice the focal length it is focused at a subject that is also 2x the focal length.

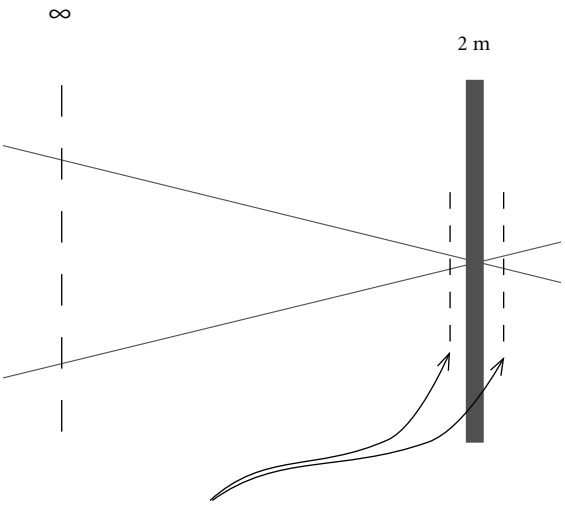


Depth of field is the area of sharp focus in front and behind the actual subject area that you are focusing on. The first thing to keep in mind about it is that the actual measurement of depth of field is a mathematical invention that describes a range of an image that is "good enough" to appear in focus. The area of sharpest focus will still be at the plane where the lens is focused—the subject does not suddenly go from in-focus to out-of-focus all at once. As different parts of an image that are farther and farther away from the plane of best focus the image of each point in the subject is focused less and less until at some point its diameter exceeds the limit you set for it. This limit, in optical formulas, is known as the *circle of confusion*. It is defined as the maximum allowable diameter for a point source of light as it begins to blur.

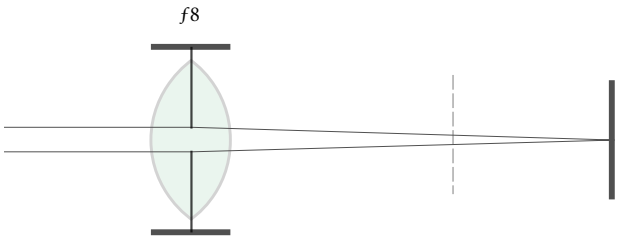
Depth of field is controlled by the aperture of your lens as you make your exposure. Although the absolute measurement of depth of field depends on the size that you use to define your allowable circle of confusion, the relative depth of field depends can be seen as a function of basic geometry, which we can illustrate like this:



1. If a lens is focused on a subject at 2 meters, the subject matter that is at infinity is being described by points that are very large—overlapping, or visually, blurring.



2. (#1 enlarged) Points in subject matter close to 2 meters is described by much smaller circles. Somewhere near the plane of sharpest focus the circles will be small enough that the image will still appear to be in focus.



3. Stopping down a lens 2 stops reduces the aperture's diameter by 1/2, so the resulting circles of confusion are also half their original diameter at any point along their focus. Stop down another 2 stops and you get another decrease in circle size and increase in apparent focus in subject matter that is away from the plane of best focus. This is a *quadrupling* of the depth of field.

*f*4 *f*22

4. Depth of field is neither a good thing nor a bad thing. It is simply an optical property that you can put to use for your particular needs if you know how to control it. If your goal is to simplify a background and isolate a subject, you have additional criteria for deciding which aperture/shutter speed combination to use.