CHAPTER/TWO camera

This section describes your camera's basic controls and what they do.

Most film cameras fall into three basic categories: view camera, rangefinder/viewfinder, and single-lens reflex. Most digital cameras are compact or single-lens reflex.

How do you keep your camera steady so that camera motion doesn't blur your picture?

Getting to the front line of action—and getting out again with photographs—is more than just a job for James Nachtwey.

Why do you need to know how a camera works? Modern camera design is based on one of the earliest camera slogans, "You press the button, we do the rest." Automatic-exposure cameras set the shutter speed, aperture, or both for you. Automatic-focus cameras adjust the lens focus. But, no matter what technological improvements claim to make a camera "foolproof" or "easy to use," there are still choices to make before you take a picture. Either you make them or the camera does, based on what the manufacturer calculates will produce the best results for an average scene.

But average results may not be what you want. You have the freedom to interpret what you see. Do you want to freeze the motion of a speeding car or let it race by in a blur? Do you want to bring the whole forest into sharp focus or isolate a single flower? Only you can make these decisions.

If you are learning photography, most instructors recommend using manual operation at first because it will speed your understanding of basic camera controls. If you do have a camera with automatic features, this book tells not just what those features do, but even more important, when and how to override an automatic mechanism and make the basic choices yourself.

Basic Camera Controls

The basic controls on all cameras are similar, helping you to perform the same actions every time you take a picture. You'll need to see the scene you are photographing, decide how much of it you want to include, focus it sharply—where you want it to be sharp—and use the shutter speed (the length of time the shutter remains open) and aperture (the size of the lens opening) to expose the sensor or film to the correct amount of light.

One of the most popular camera types is shown here—the single-lens reflex. Other basic camera designs are described later in this chapter.

As the camera's settings change, the picture changes also. What will a scene look like at a faster shutter speed or a slower one? How do you make sure the background will be sharp—or out of focus—if you want it that way? Once you understand how the basic camera controls operate and what your choices are, you will be better able to get the results you want, rather than simply pressing the button and hoping for the best.

DIGITAL CAMERA

An array of controls on this single-lens reflex digital camera *lets you make settings manually or automatically, and view (and delete if you wish) the photograph you have just made or any others on its memory card.*

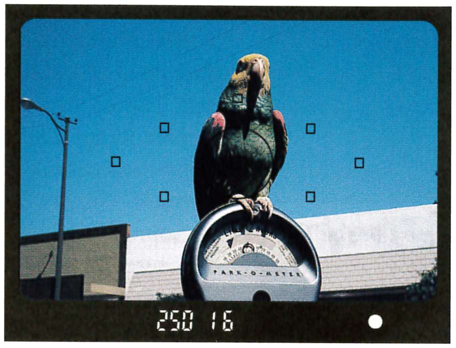
MANUAL FILM CAMERA

Manually adjusted controls *on this 35mm single-lens reflex camera let you set the shutter speed (the length of time the shutter remains open), select the lens aperture (the size of the lens opening), focus on a particular part of the scene, and change from one lens to another.*

AUTOMATIC FILM CAMERA

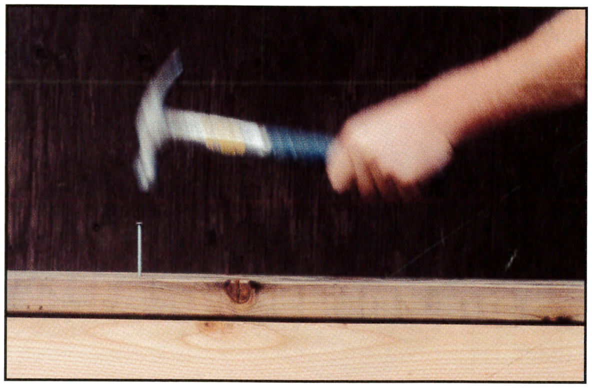
On automatic cameras, *control keys often replace adjustable knobs or rings. This model automatically adjusts the focus, shutter speed, and aperture. You can override the automatic features if you want to adjust the camera's settings yourself. Built for professionals, it has a complete system of lenses and accessories.*

Viewfinder image



__The viewfinder__ shows you the entire scene that will be recorded and indicates which part of the scene is focused most sharply. The viewfinder usually displays exposure information—here the shutter speed (1/250) and aperture (f/16).

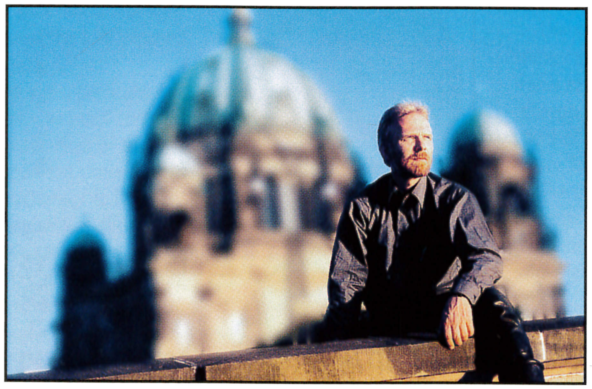
Slow shutter speed



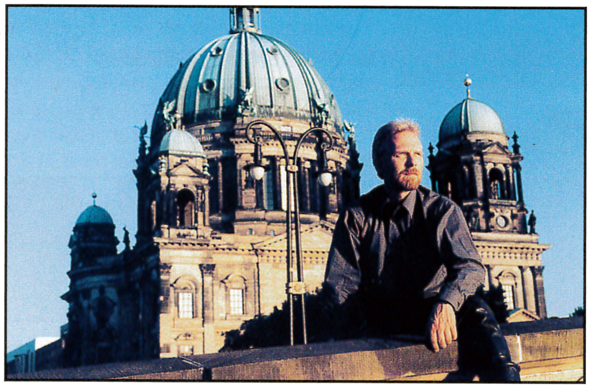
Fast shutter speed

__The shutter-speed selector__ controls the length of time that the shutter remains open. A shorter time decreases the likelihood that a moving object will appear blurred.

Large aperture opening

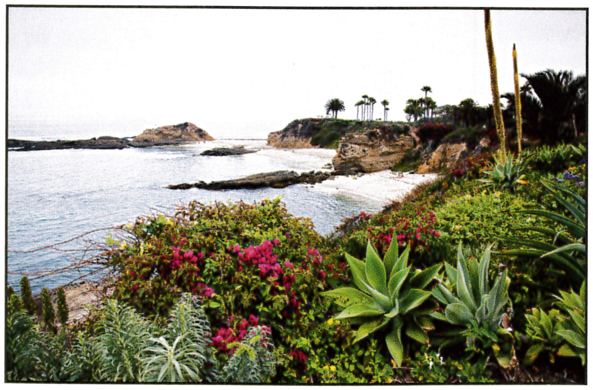


Small aperture opening



__The aperture selector__ adjusts the size of the lens opening—created by the blades of the diaphragm. The smaller the aperture opening, the greater the depth of field (the part of the scene from near to far that will be sharp).

Short-focal-length lens



Long-focal-length lens

__Interchangeable lenses__ let you select the lens focal length, which controls the size of objects in the picture and the extent of the scene that will be recorded on the film or captured digitally.

Two controls adjust the amount of light that reaches the sensor or film: the shutter, described here, and the aperture (pages 24–25). The combination of an aperture and a shutter speed is an *exposure*, which must be a correct one so your picture is neither too light nor too dark.

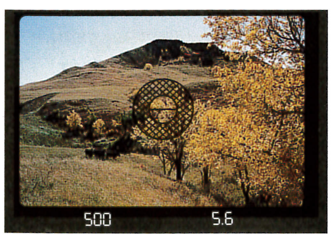
Adjusting the length of time the shutter remains open controls the amount of light that reaches the light-sensitive surface. Doubling the amount of time it is open gives one stop more exposure—twice the amount of light. Halving the amount of time gives one stop less exposure—half the amount of light. Each full-stop shutter setting is half (or double) the time of the next one and is marked as the denominator (bottom part) of the fraction of a second that the shutter remains open: 1 (1/1 or one second), 2 (1/2 second), 4 (1/4 second), and so on through 8, 15, 30, 60, 125, 250, 500, 1000 or higher. Some cameras have shutters that reach 1/8000 of a second. B (bulb setting) keeps the shutter open as long as the release button is held down. T (time setting) opens the shutter with one press of the release, and closes it with another.

Electronically controlled shutters can operate at any speed, for example, 1/38 second. These “stepless” speeds are set by the camera in automatic exposure operation; some cameras allow you to dial them in yourself—others don’t.

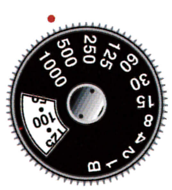
Some digital cameras use a shutter for exposure. Others use them only to block light when the sensor needs darkness; they control exposure by turning the sensor on and off for a precisely-timed duration (see How Shutters Work, opposite).

NOTE: The term “stop” in photography refers to a change in illumination, whether the shutter speed or the aperture is changed to achieve it. To give one stop more exposure means to double the amount of light reaching the light-sensitive surface, either by doubling the exposure time or by doubling the size of the aperture (see page 25). To give one stop less exposure means to cut the light reaching the sensor or film in half by halving the exposure time or by halving the size of the aperture.

WHERE SHUTTER SPEED SETTINGS ARE DISPLAYED ON VARIOUS CAMERAS



In the camera’s viewfinder



On the shutter-speed dial

In the data-panel readout

***For the above examples,** each camera is set to 1/500 sec. Notice that the camera displays only the bottom number of the fraction.*

SHUTTER SPEEDS—WHAT YOU SEE AND WHAT YOU GET

Cameras used to provide shutter speeds only in full stops. Older mechanical shutters could only provide a modest number of settings so they were made only to let in light for double the amount of time of the shutter speed before it or half that of the one after it. Cameras today with electronically controlled shutters will also set shutter speeds in between. Most cameras display increments of one-half or one-third stops and allow you to choose which of those you see. This chart shows how long each full stop remains open, plus how your camera may display fractional stops.

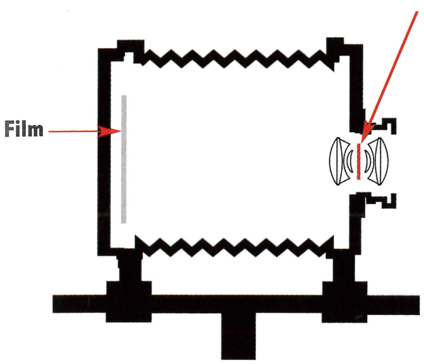
Many of these numbers are rounded off. Don’t be surprised by inconsistency in shutter speeds among camera manufacturers. For example, an exact half-stop setting between 1 and 2 should be the square root of two, approximately 1.4142. One camera displays this as 1.4, another as 1.5.

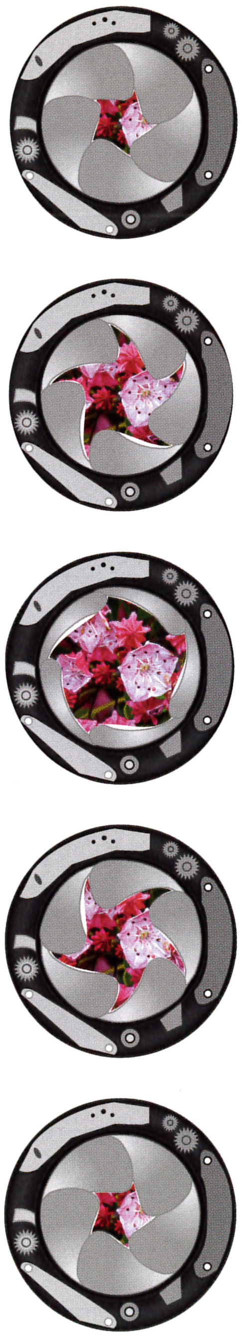
NOTE: Don’t confuse 2, meaning 2 seconds, with 2, meaning 1/2 second; 4, meaning 4 seconds, with 4, meaning 1/4 second, and so on. Your camera will indicate a difference between fractions and whole numbers in its viewfinder and data-panel shutter-speed display, usually with a mark that appears next to the whole seconds like 2”. Make sure you know the symbol your camera uses.

If your camera allows you to choose among different ways to set shutter speeds, use full stops while learning photography. Do the same with aperture settings (see page 24).

Actual time in seconds	Shutter speeds your camera may display		
	FULL STOP	**1/3 STOP**	**1/2 STOP**
1 sec	**1**	**1**	**1**
		1.3	1.5
		1.6	
1/2 sec	**2**	**2**	**2**
		2.5	3
		3	
1/4 sec	**4**	**4**	**4**
		5	6
		6	
1/8 sec	**8**	**8**	**8**
		10	11
		13	
1/15 sec	**15**	**15**	**15**
		20	20
		25	
1/30 sec	**30**	**30**	**30**
		40	45
		50	
1/60 sec	**60**	**60**	**60**
		80	90
		100	
1/125 sec	**125**	**125**	**125**
		160	180
		200	
1/250 sec	**250**	**250**	**250**
		320	350
		400	
1/500 sec	**500**	**500**	**500**

HOW SHUTTERS WORK



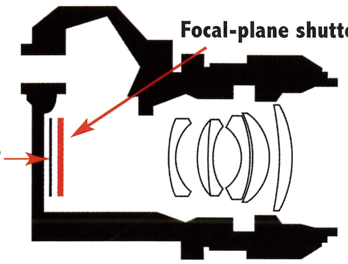


A leaf or between-the-lens shutter is generally located inside the lens itself. All view cameras, many medium-format cameras, and most compact cameras use leaf shutters. The leaf shutter consists of a number of small overlapping metal blades. As shown at right, when the shutter is released, the blades open up for an amount of time determined by the selected shutter speed, then shut again. The total amount of light admitted during this cycle produces the fully exposed photograph (see top of the page).

Many compact digital cameras use a particular kind of CCD sensor (called interline transfer) that controls the length of exposure electronically. Most of these have a leaf shutter that is normally open, but closes momentarily before exposure to allow the sensor to initialize.

Advantages/Disadvantages. A leaf shutter is quieter than a focal-plane shutter and can be used with flash at any shutter speed. But because the leaf shutter has to open, stop, and then reverse direction to close again, most have top speeds no higher than 1/500 second. If your interchangeable-lens camera uses leaf shutters, the shutter is probably built into the lens. The cost of a shutter then adds to the price of each lens. Also, actual shutter speeds for the shutter in one lens might be a little slower or faster than those for the shutter in another. Generally, the difference is small, but it could be enough to make a noticeable difference in exposure when changing from one lens to another.

Because a leaf shutter only has to open until it reaches the outer edge of the aperture, many cameras can set a higher shutter speed for small apertures than for large ones. Leaf shutters are so quiet that many compact digital cameras are programmed to emit an electronic shutter-like sound when the button is pressed so the user can tell when an exposure has been made.



A focal-plane shutter is built into the camera body and is located directly in front of the sensor or film; it consists of two overlapping curtains. When the shutter is released at slow shutter speeds, the first (opening) curtain moves across the frame, revealing a window through which the sensor or film is exposed. The shutter waits for the correct amount of time, then it closes the second (following) curtain to stop the exposure. At higher shutter speeds, the following curtain begins to close before the opening curtain has completed its travel. The film or sensor is exposed through what appears to be a moving slit. As the shutter speed increases, this slit narrows.

The series to the right shows the shutter travel at fast shutter speeds. The narrow slit exposes only part of the frame at any one time, but every part of the sensor or film receives light for the same amount of time. Above, see the effect of the entire exposure, with all sections of the sensor or film having received the proper amount of light.

The shutter shown here moves from side to side. Some cameras have another type of focal-plane shutter (called a guillotine) that moves from top to bottom. Some digital single-lens reflex cameras use an interline transfer CCD sensor (see text at left). They also have a focal-plane shutter but do not use it to control the length of exposure.

Advantages/Disadvantages. Interchangeable lenses for a camera with a focal-plane shutter can be less expensive than those for cameras requiring leaf shutters, because a shutter does not have to be built into each lens. And focal-plane shutters can reach higher speeds than leaf shutters—as high as 1/8000 sec.

Generally, however, you can't use electronic flash when both shutter curtains are moving at the same time. The highest shutter speed at which the opening curtain has completed its travel before the following curtain begins to move—called the sync speed—may be as slow as 1/60 second. At any faster shutter speed than a camera's sync speed, a flash will illuminate only the slice of the frame revealed by the slit at the moment the flash is triggered.

Because you must use a relatively slow shutter speed with flash, bright existing (or ambient) light may register on the film or sensor as well as light from the flash. This can leave a "ghost" or second image in the picture.

The faster the shutter speed, the sharper a moving subject will be. A blurred image can occur when an object moves during an exposure, because its image projected onto the sensor or film by the lens will move during the time the shutter is open. If the object moves swiftly, or if the shutter is open for a relatively long time, this moving image will blur and be indistinct. But if you increase the shutter speed, you can reduce or eliminate the blur. You can control this effect and use it to your advantage. A fast shutter speed can freeze a moving object, showing its position at the instant of exposure (see opposite page). You can use a slower shutter speed to increase blurring and accentuate the feeling of motion (see pages 22 and 23). Generally, the amount of motion blur will double if you increase the shutter speed by one stop (toward a longer time).

Shown below are the effects of varying shutter speed and camera movement. In the picture at far left, the go-kart moved enough during a relatively long exposure of 1/30 second to leave a broad blur in the image. In the next photograph, at a shutter speed of 1/500 second, the car and driver are much sharper. A moving subject may vary in speed and thus affect the shutter speed needed to stop motion. For example, motion slows and sometimes stops at the peak of a movement that reverses, such as the peak of a jump just before descent (opposite page), and even a relatively slow shutter speed will record the action sharply.

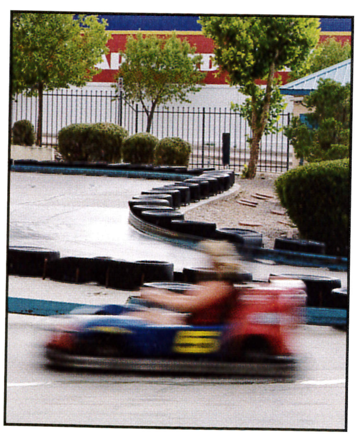
Other factors besides shutter and subject speed also affect the amount of blurring in a photograph. What matters is how far an image actually travels across the sensor or film during the exposure. In the photograph below of the driver heading directly toward the camera, the go-kart's image remains in virtually the same position in the frame. Thus there is far less blurring even at 1/30 second. A subject close to the camera that is moving slowly, such as someone walking 10 feet away, will cross more of the film or sensor and appear to blur more than the same subject moving at the same speed but farther away.

A long-focal-length lens magnifies objects and makes them appear closer to the camera. A moving subject will appear more blurry when photographed with a long lens than it would if photographed with a normal lens used at the same distance.

Panning keeps a moving subject sharp while blurring the background. In the picture below, right, the camera was moved (panned) in the same direction the vehicle was moving. Since the camera moved along with the go-kart, the driver appears sharp while the motionless background appears blurred. Successful panning takes both practice and luck. Variables such as the exact speed and direction of the moving object make it difficult to predict exactly how fast to pan. Decide where you want the object to be at the moment of exposure, start moving the camera a few moments before the object reaches that point, and continue the motion after the exposure (follow-through) as you would with a golf or tennis stroke. The longer the focal length of the lens, the less actual camera movement will be necessary.

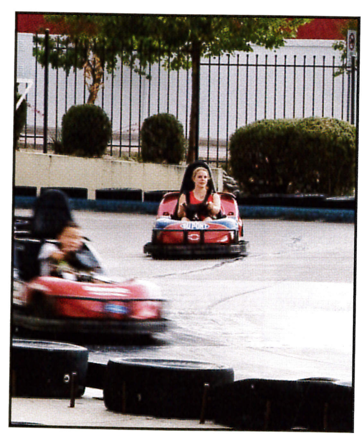
DIRECTION OF A MOVING OBJECT AFFECTS THE AMOUNT OF BLUR

1/30 second

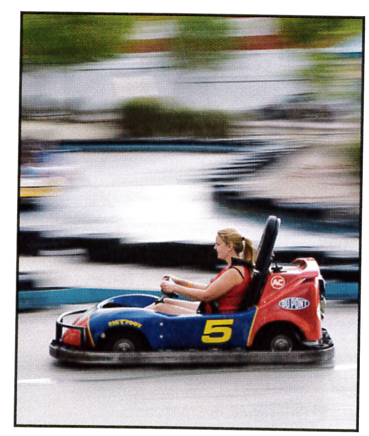


1/500 second

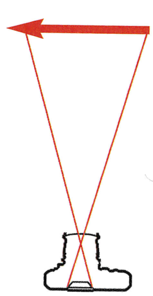
1/30 second



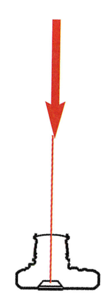
1/30 second, camera panned

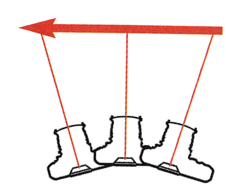


When a subject is traveling parallel to the plane of the film or sensor, *considerable movement is likely to be recorded on the film. The subject will be blurred, unless the shutter speed is fast.*

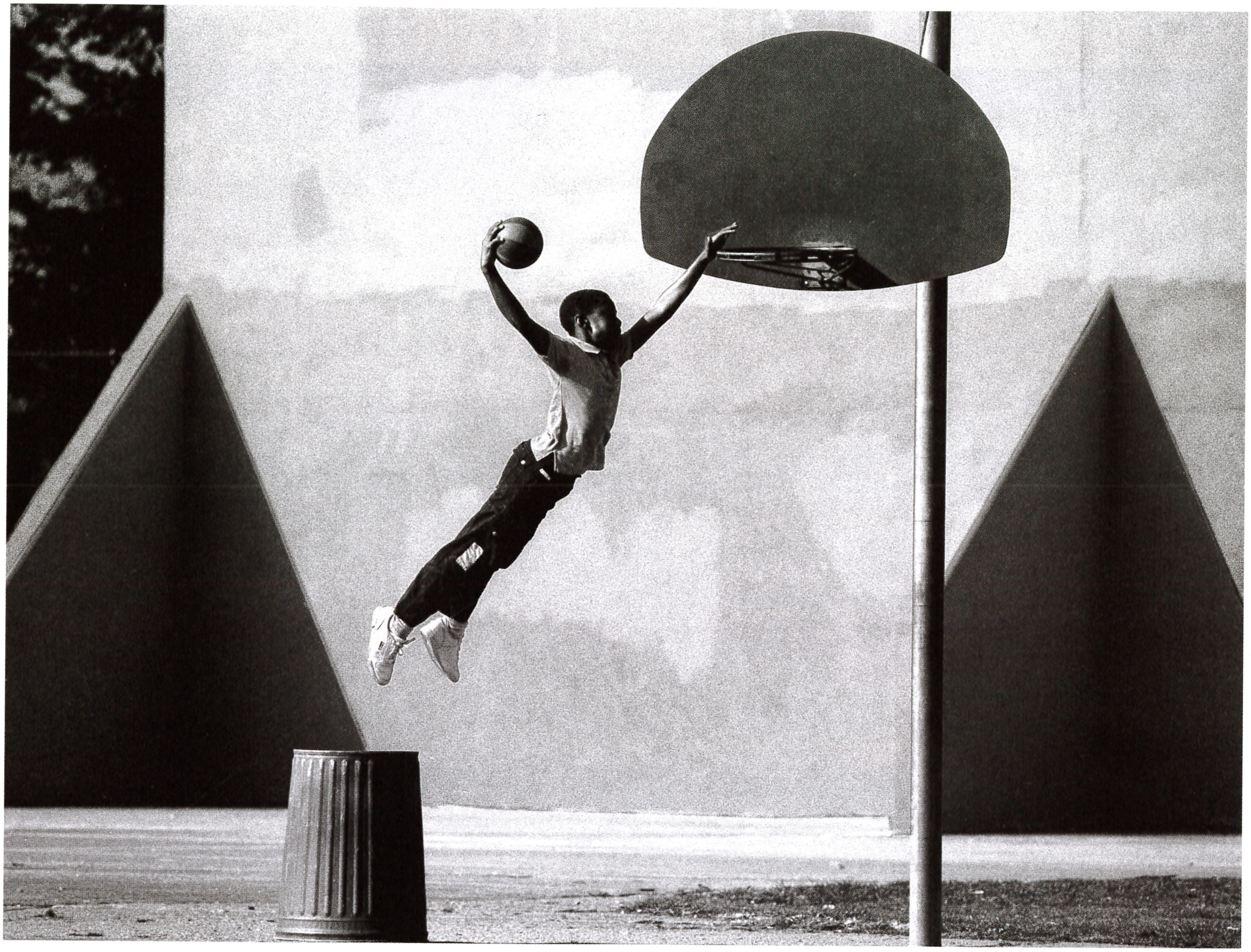


If the subject is moving directly toward or away from the camera, *no sideways movement is recorded so a minimum of blur is produced, even at a relatively slow shutter speed.*





During panning, the camera is moved in the same direction as the subject. *The result is a sharp subject and a blurred background.*



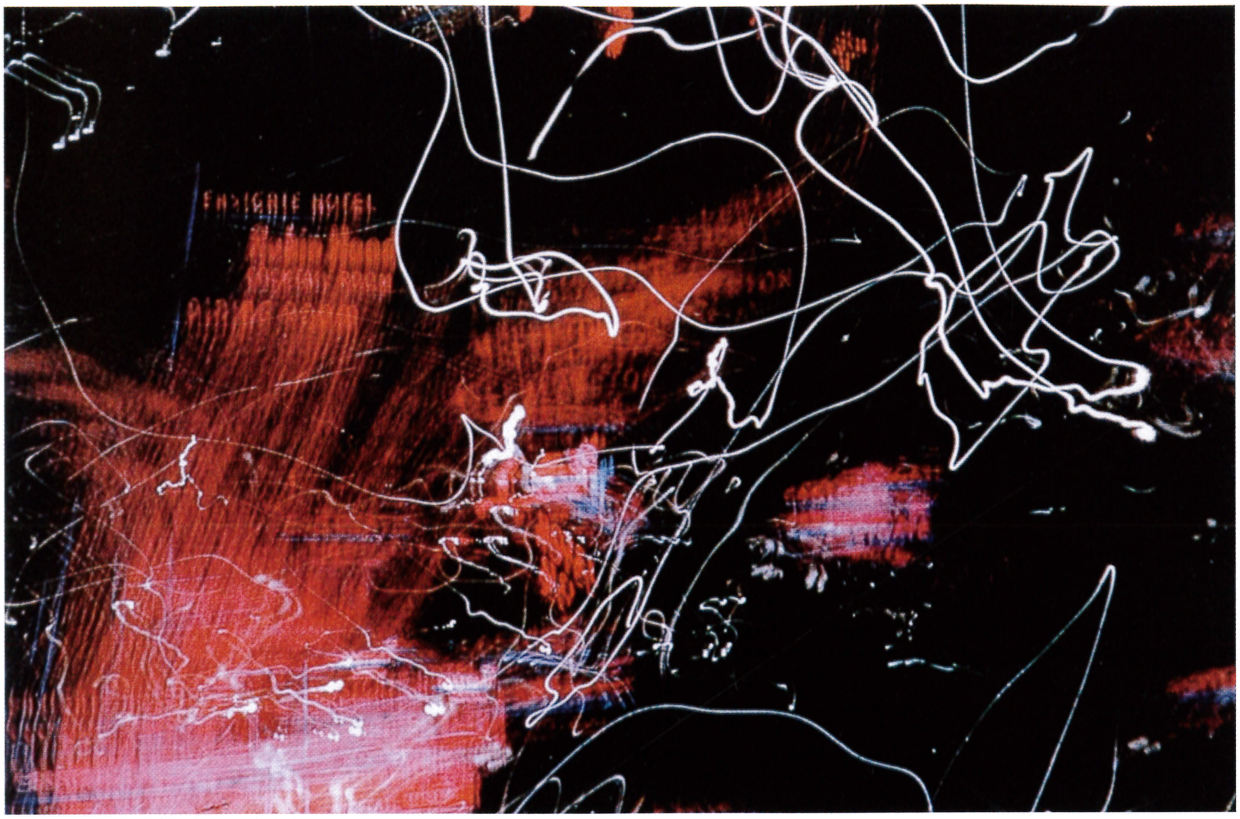
CLIFFORD OTO Slam Dunk, 1990

Motion slows at the peak of an action that reverses, *such as this leap into the air. At that moment of slower movement, the shutter speed doesn't have to be as fast to show the motion sharply. Here the boy jumps from an overturned garbage can for a slam dunk.*

The key word in photographing action is anticipation. What direction is the subject moving? Where should you be focused? When might an interesting moment occur? Think about what is going to happen, rather than trying to catch up to what has already happened.

SHUTTER SPEEDS TO STOP ACTION PARALLEL TO THE IMAGE PLANE

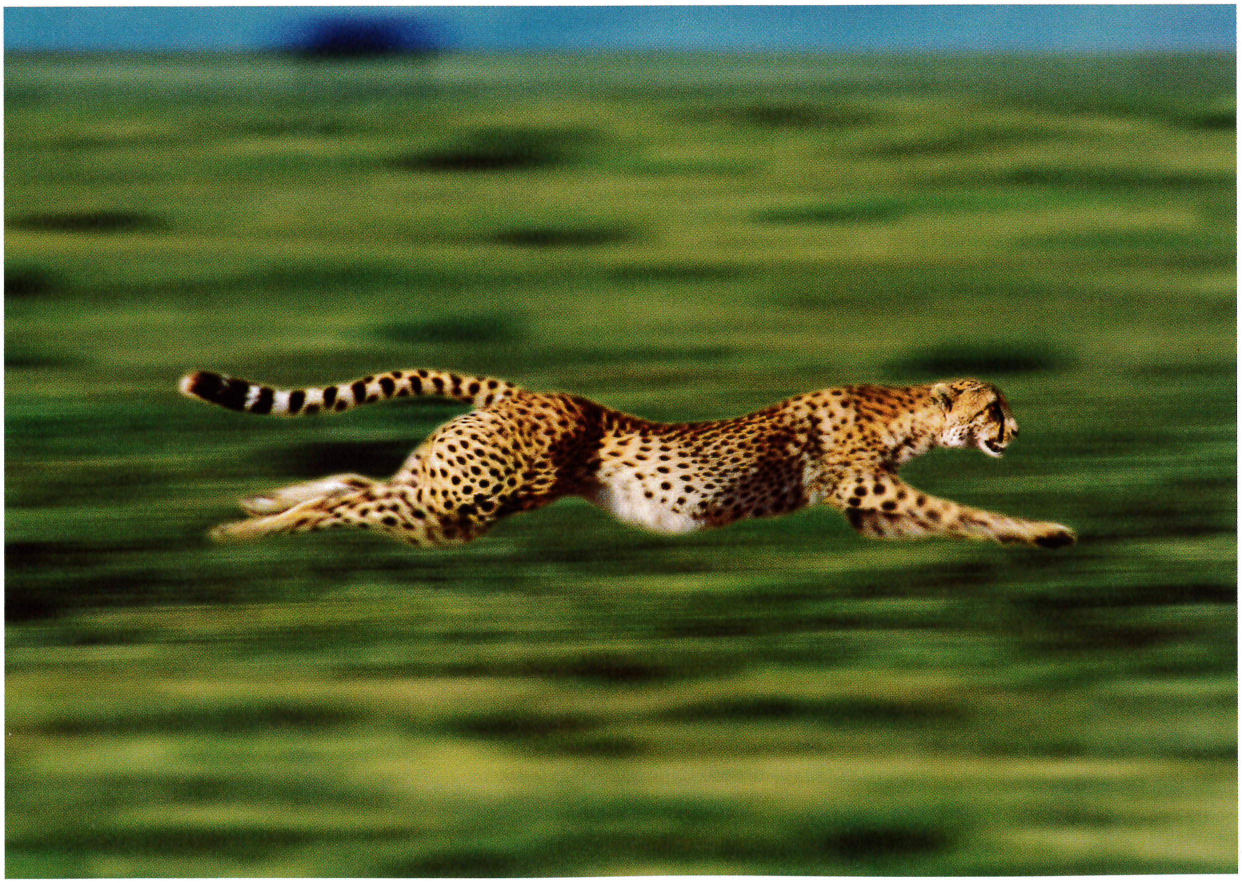
Type of Motion	Speed	Camera-to-Subject Distance		
		25 feet	50 feet	100 feet
Very fast walker	(5 mph)	1/125	1/60	1/30
Child running	(10 mph)	1/250	1/125	1/60
Good sprinter	(20 mph)	1/500	1/250	1/125
Speeding car	(50 mph)	1/1000	1/500	1/250
Airplane		______	______	1/1000



Here are three ways to represent movement. Each provides a different opportunity for a creative response to motion, as an alternate to simply attempting to freeze it. The camera moves against a stationary subject (top), camera and subject are both in motion (bottom), and the camera is held still while the subject moves (opposite).

LÁSZLÓ MOHOLY-NAGY
Untitled, c. 1941

An inveterate experimentalist, Moholy-Nagy used camera movement and a long exposure at night to explore an entirely abstract world of color and shape. *The New Bauhaus school he started in Chicago encouraged experimentation in all media, and was especially important for paving the way for today's wide acceptance of photography in higher education.*



STEVE BLOOM
Running Cheetah, Masai Mara, Kenya, 1998

Panning (moving the camera to follow the subject) is an effective way to separate the subject from the background. *Bloom's 600mm lens followed the cheetah as it chased a young gazelle. Even at a shutter speed of 1/250 second, the movement of the camera was enough to turn the background into a blurred field that isolates the fastest animal on land. "Following them while keeping them in focus is a challenge," Bloom admits.*

OLIVIER FÖLLMI Pilgrimage to Bodghaya, India, 2002

A long exposure blurred the moving flags, while rendering sharply the praying figure. *Föllmi used the chaos of blurred color to contrast with the serenity of the subject's contemplative moment.*

NUBAR ALEXANIAN
Patty Larkin,
Philadelphia, 1994

A fast lens, one that opens to a wide aperture, is useful in dim light, such as indoors. *A wide aperture lets you set a shutter speed fast enough so that you don't have to use a tripod to keep the camera steady. It is also useful when photographing action by letting you shoot at a fast enough shutter speed to show moving subjects sharply.*

The aperture (the size of the lens opening) controls the brightness of the light that reaches the sensor or film. The aperture works like the pupil of an eye, enlarging or contracting to admit more light or less. In a camera lens, the diaphragm—a ring of thin, overlapping metal leaves located inside the lens—is the mechanism that controls the size of the aperture. Its movable leaves can be opened wide to let in more light or closed down to let in less (see opposite).

The size of an aperture is indicated by its f-number or f-stop. On early cameras the aperture was adjusted by individual metal "stop" plates that had holes of different diameters. The term stop is still used to refer to the aperture size, and a lens is said to be "stopped down" when the size of the aperture is decreased.

Part of the standardized, full-stop series of numbers on the f-stop scale is shown in the box, right. The smaller numbers correspond to the larger apertures, and admit the most light. Each larger-numbered full f-stop (shown in boldface) admits half the light of the previous one. A lens that is set at f/4 admits half as much light as one set at f/2.8 and only a quarter as much as one set at f/2. (Notice that f-stops have the same half or double relationship that full-stop shutter-speed settings do.)

The full-stop numbers continue in both directions. Wider apertures, for example f/1 or f/0.7, are possible but such lenses are too expensive for general use. Smaller ones—f/32, f/45, f/64, f/90—are seen only on specialized lenses. The change in light over the full range of f-stops is large; a lens whose aperture is stopped down to f/64 admits less than 1/4000 of the light that comes through a lens set at f/1.

Few lenses provide a range of apertures greater than eight stops. A general-purpose lens for a single-lens reflex camera, for example, might run from f/1.4 to f/16. A camera lens designed for a large view camera might stop down to f/64 but open up only to f/5.6. **NOTE:** The widest possible aperture on your lens may not be a standard full stop. A lens's f-stops may begin with a setting such as f/1.2, f/3.5, or f/7.7, then proceed from the next full stop in the standard sequence.

Lenses are often described as fast or slow. These terms refer to the width of the maximum aperture for the lens. A lens that opens to f/1.4 opens wider and is said to be faster than one that opens only to f/2. Faster lenses allow you to shoot more easily in low light or at higher shutter speeds. They also are more expensive than slower lenses.

F-STOPS: CONTROLLING THE SIZE OF THE LENS APERTURE

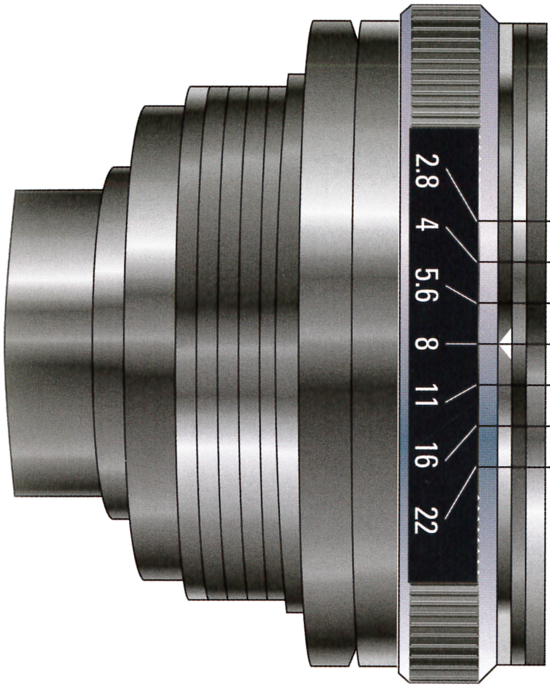
Lenses come with a limited range of apertures (f-stops) usually marked in full stop increments. Each full stop lets in half the amount of light as the one before it and double that of the one after it. (Note that the smaller the f-number, the larger the lens opening.) Apertures are continuously variable; on many cameras they can be set anywhere in between full stops. But your lens or display may only indicate one-half or one-third stop increments.

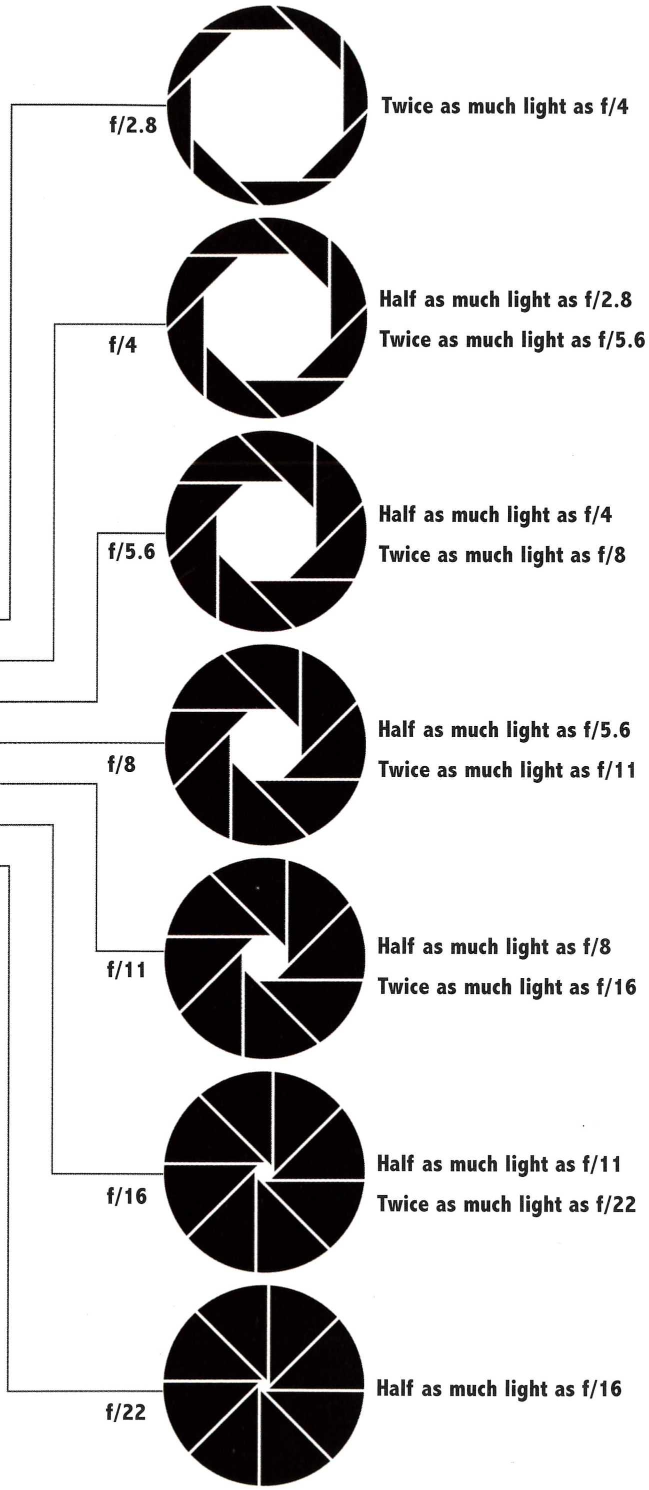
This chart shows a range of full and fractional aperture openings. Not all cameras number the fractional apertures exactly as shown. If your camera allows you to choose among different ways to set apertures, using full stops will be less confusing while you learn photography.

Apertures in full stops	1/2 stop	1/3 stop
f/1.4	**f/1.4**	**f/1.4**
	f/1.7	f/1.6
		f/1.8
f/2	**f/2**	**f/2**
	f/2.3	f/2.2
		f/2.5
f/2.8	**f/2.8**	**f/2.8**
	f/3.4	f/3.2
		f/3.5
f/4	**f/4**	**f/4**
	f/4.7	f/4.5
		f/5
f/5.6	**f/5.6**	**f/5.6**
	f/6.7	f/6.3
		f/7.1
f/8	**f/8**	**f/8**
	f/9.5	f/9
		f/10
f/11	**f/11**	**f/11**
	f/13	f/13
		f/14
f/16	**f/16**	**f/16**
	f/19	f/18
		f/20
f/22	**f/22**	**f/22**
	f/27	f/25
		f/28

The size of the lens opening—the aperture or f-stop—controls the amount of light that passes through the lens. The lens shown here has apertures from f/2.8 to f/22. Each setting is one stop from the next; that is, each lets in twice as much light as the next smaller opening, half as much light as the next larger opening.

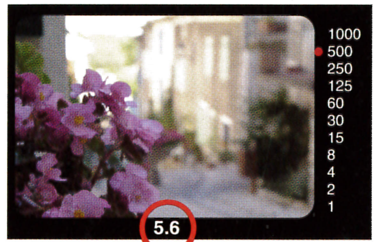
The higher the f-stop number, the smaller the lens opening and the less light that is let in. On this lens, f/2.8 is the largest opening and lets in the most light. As the numbers get bigger (4, 5.6, 8), the aperture size gets smaller and the amount of light admitted decreases.





NOTE: ***Some lens barrels do not display the apertures as shown above.*** *Rather than twisting a ring on the lens to set the aperture, you dial in the setting on the camera body. Regardless of how you change the aperture, though, you are still changing the size of the lens opening and thus the intensity of light that strikes your film or sensor.*

WHERE APERTURE SETTINGS ARE DISPLAYED ON VARIOUS CAMERAS

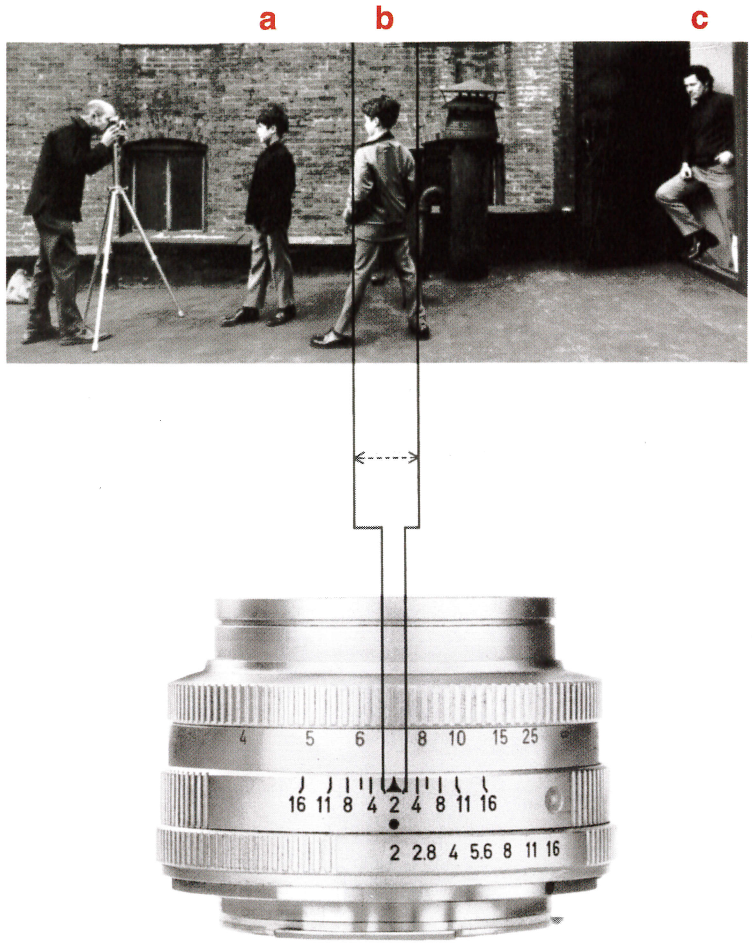


In the camera's viewfinder

In the data-panel readout

On the lens barrel

LARGE APERTURE, LESS DEPTH OF FIELD



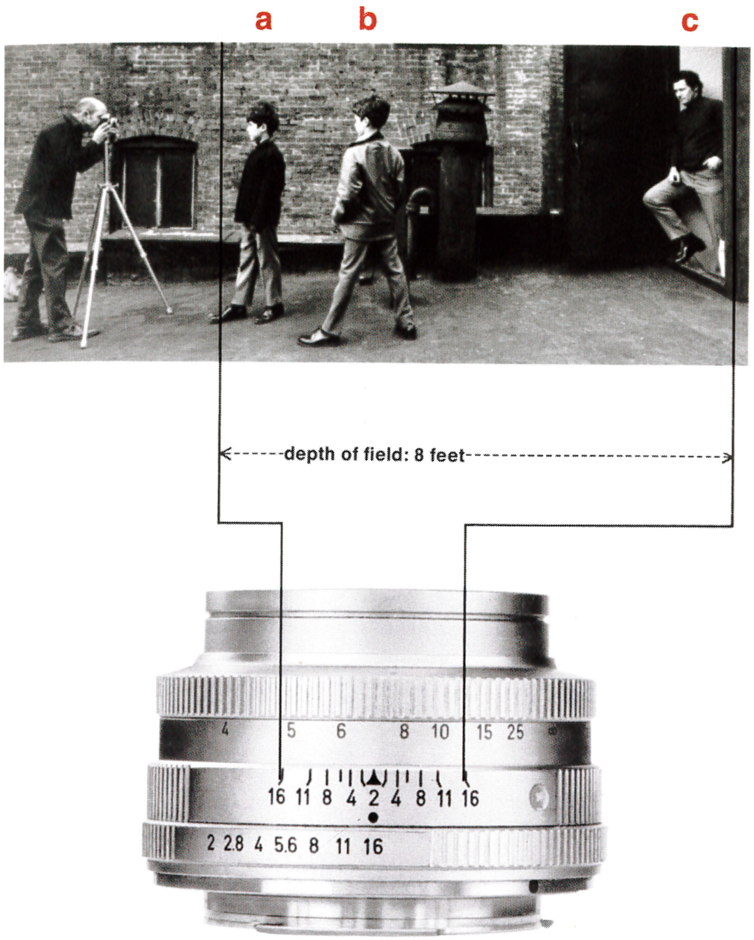
The smaller the aperture size, the more of a scene that will be sharp from near to far. As the aperture is stopped down and gets smaller, more of the background and foreground in a given scene becomes sharp. The area of acceptable sharpness in a picture is known as the depth of field.

The two larger photographs shown on these pages were taken under identical conditions but with different aperture settings. In the photograph above, the diaphragm was opened to its widest aperture, f/2, and the lens was focused on the boy (b) about seven feet away (see side view of photographer Duane Michals and his subjects, above right). The resulting photograph shows a shallow depth of field; only the middle boy (b) is sharp, while both the boy in front (a) and the man behind (c) appear out of focus. Using a small aperture, f/16, gives a different picture (opposite page). The lens is still focused on the middle boy, but the depth of field has increased enough to yield sharp images of the other figures as well.

Some types of cameras let you see the extent of the depth of field. With a view camera, you look directly through the lens. As the lens is stopped down, the increasing sharpness is visible on the ground-glass viewing screen. A single-lens reflex camera also allows you to look directly through the lens. But most models, regardless of which aperture is selected, will automatically show the scene through the widest aperture. They are designed this way because looking through the lens at its widest aperture gives you the brightest possible view for framing and focusing.

Depth of field is the area from near to far in a scene that is acceptably sharp in a photograph. *As the aperture changes, the depth of field changes. If your lens has a depth-of-field scale (many do not), you can use it to estimate the extent of the depth of field. On this lens, the bottom row shows the aperture (f-stop) to which the lens is set. The top ring shows the distance on which the lens is focused. The paired numbers on the middle ring correspond to f-stops and show the nearest and farthest distances the depth of field covers when the lens is set at various f-stops.*

Here, the lens is set to its widest aperture, *f/2, and focused on the middle boy (see side view of scene above), who is at a distance of 7 ft. The depth of field extends from more than 6 ft to less than 8 ft; only objects within that distance will be acceptably sharp. If depth of field is shallow, as it is here, a lens can be sharply focused on one point and still not produce a picture that is sharp enough overall.*



When the lens is stopped down to its smallest aperture, here f/16, the depth of field increases. *Almost the entire scene—everything between about 5 ft and 13 ft—is now sharp at the same focusing distance of 7 ft.* **NOTE:** *The bigger the f-stop number, the smaller the lens opening (you can see this illustrated on page 25); f/16 is a smaller aperture than f/2.*

SMALL APERTURE, MORE DEPTH OF FIELD

Looking through the widest aperture also means you see the scene with the least possible depth of field. Some cameras provide a depth-of-field preview button that stops down the lens so that the viewfinder image shows the depth of field at the aperture you have selected. However, stopping down the lens reduces the brightness of the viewfinder image. In dim light or at a very small aperture, that image may become too dark to be seen clearly, but single-lens reflex film cameras and view cameras do give you a way to check depth of field visually at all apertures. With a digital camera you can make (and later delete) a test shot to evaluate depth of field from the monitor display.

Other camera designs show the scene differently. Rangefinder and some compact camera designs have a window in which you frame your shot. Through this viewfinder, objects at all distances appear equally sharp.

Some lenses have a depth-of-field scale from which you can estimate the depth of field. This scale is printed on the lens as paired numbers that bracket the distances of the nearest and farthest points of the depth of field. As the lens is focused and the f-stop set, the scale shows approximately what part of the picture will be in focus. (See the lenses at left.) The farthest distance marked on the lens appears as the symbol ∞. When this infinity mark appears within the depth of field shown on the scale, all objects beyond the closest distance in focus will be sharp.

Look up the depth of field in a table if your lens has no scale. Published tables give depth of field for every focal length, aperture, and distance. Check a library or online; see page 58 for more.

Both shutter speed and aperture affect the amount of light entering the camera. To get a correctly exposed picture (one that is neither too light nor too dark), you need a combination of shutter speed and aperture that lets in the right amount of light for a particular scene and particular ISO speed.

Equivalent exposures. Once you know a combination of shutter speed and aperture that will let in the right amount of light, you can change one setting as long as you change the other in the opposite way. When using full stops, each aperture setting lets in twice as much light as the next smaller opening (larger-numbered setting). Each shutter speed lets in twice as much light as the next faster speed. (See photographs at right.) You can use a larger aperture if you need a faster shutter speed, or you can use a smaller aperture if you want a slower shutter speed. The same amount of light is let in by the combination of f/16 aperture at a 1/8-second shutter speed, as by f/11 at 1/15 second, and so on. This back-and-forth balance is called a reciprocal relationship.

Shutter speed and aperture also affect sharpness, but act differently. Shutter speed affects the sharpness of moving objects; aperture affects depth of field, sharpness from near to far. Their different effects are shown in the three photographs at right. In each, the lens was focused on the same point, and shutter speed and aperture settings were balanced to admit the same total amount of light into the camera. But the equivalent exposures resulted in very different photographs.

In the first picture, a small aperture produced considerable depth of field that rendered background details sharply. But the shutter speed needed to compensate for this tiny aperture had to be so slow that the rapidly moving flock of pigeons appears only as indistinct ghosts. As the aperture was set wider and the shutter speed faster in the middle photo, the background is less sharp, but the pigeons are visible, though still blurred. At far right, a still larger aperture and faster shutter speed sacrificed almost all background detail, but the birds are now very clear, with only a few wing tips still blurred.

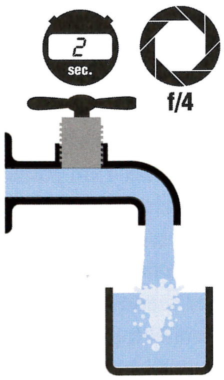
A BUCKET OF LIGHT

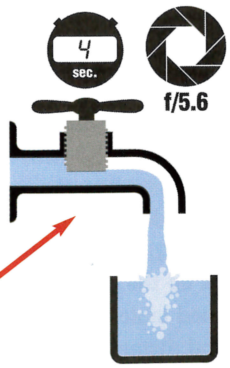
The quantity of light that reaches the film or sensor inside a camera depends on both aperture size (f-stop) and exposure time (shutter speed).

How long does it take to fill a bucket with water flowing from a faucet? That depends on how wide the faucet is open and how long the water flows. If the wide-open faucet fills the bucket in 2 seconds, then the same bucket will be filled in 4 seconds from a half-open faucet. But regardless of how long it takes to fill the bucket, the bucket always holds the same amount of water.

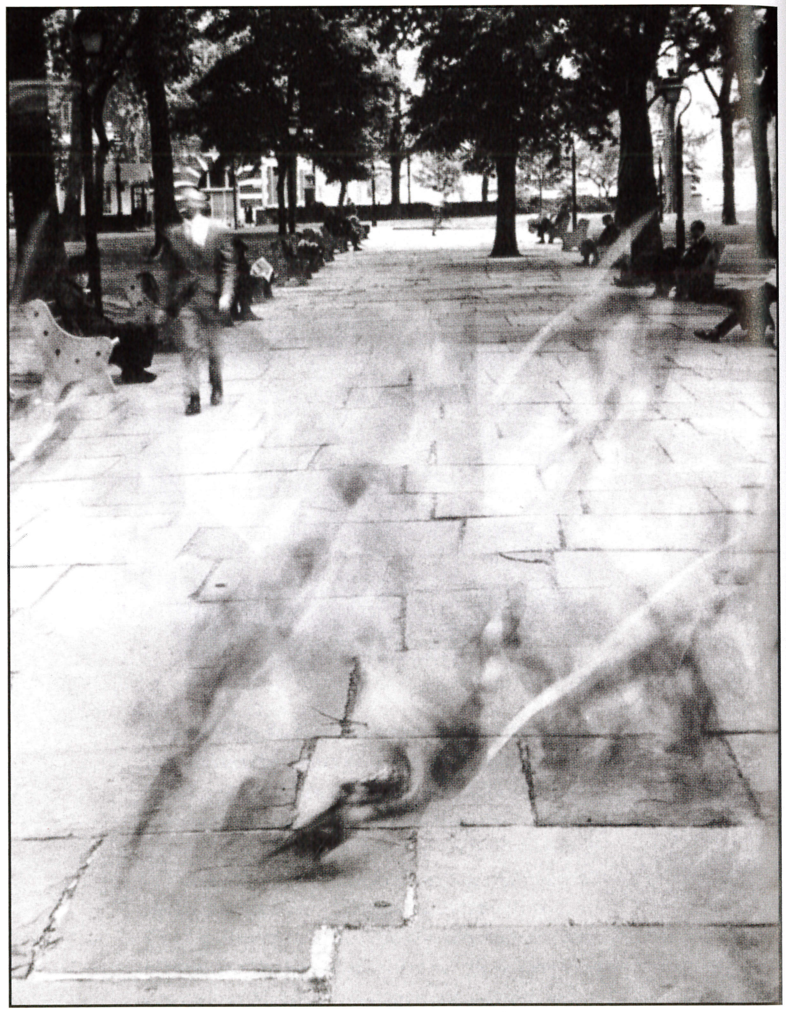
Film and digital sensors are like these buckets. To be properly filled with light (exposed), each always requires the same amount—the same number of "gallons"—of light.

If the correct exposure for a scene is 2 sec at f/4, you get the same total amount of exposure with twice the length of time (next slower shutter speed) and half the amount of light (next smaller aperture)—4 sec at f/5.6.

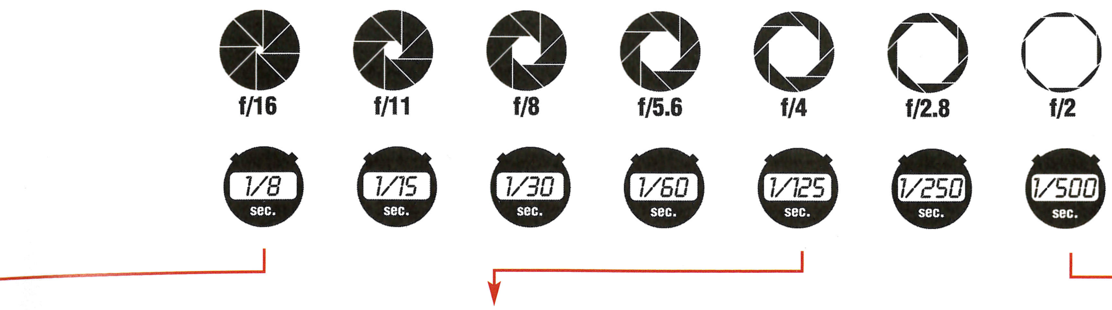




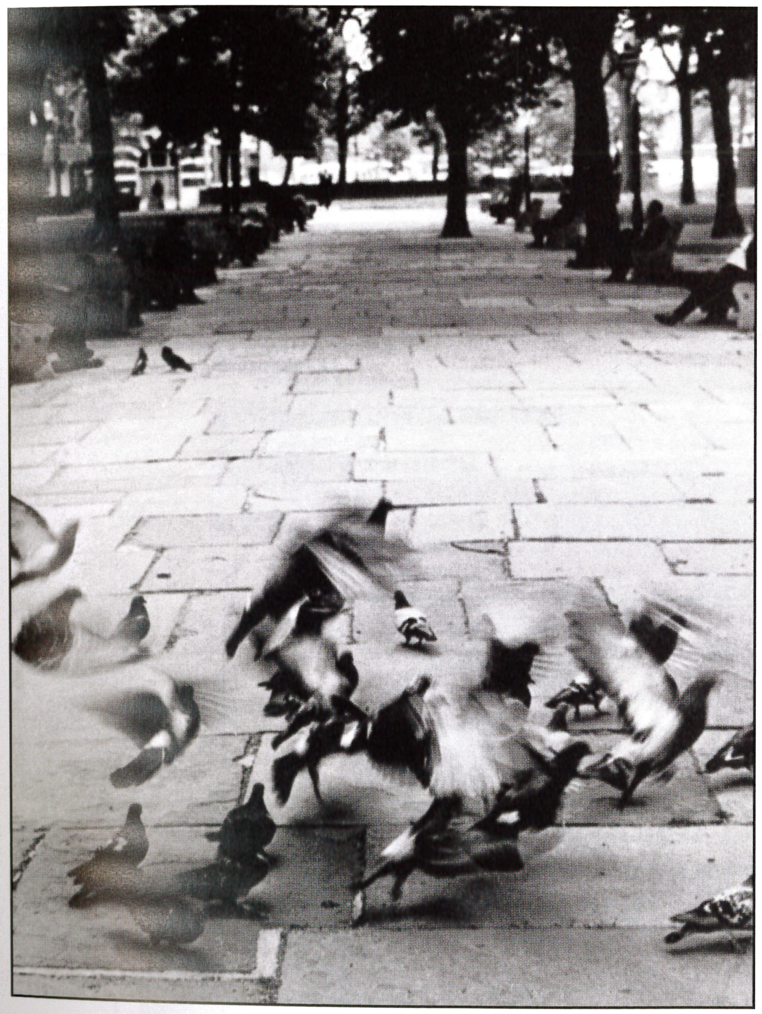
Compared to the top illustration, the same amount of water is delivered when half the volume of water runs for twice the length of time.



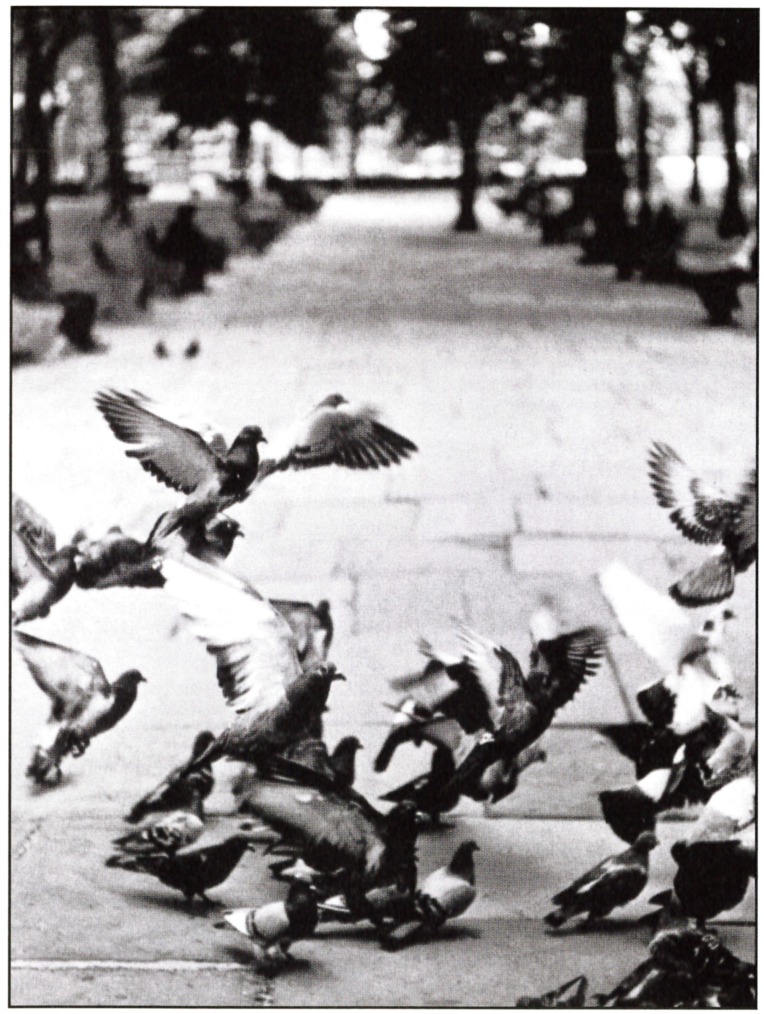
Small aperture (deep depth of field), slow shutter speed (motion blurred). *In this scene, a small aperture (f/16) produced great depth of field; the nearest paving stones as well as the farthest trees are sharp. But to admit enough light, a slow shutter speed (1/8 sec) was needed; it was too slow to show moving pigeons sharply. It also meant that a tripod had to be used to hold the camera steady.*



Equivalent exposures. *Each combination here of f-stop and shutter speed produces the equivalent exposure (lets in the same amount of light) but produces differences in depth of field and motion.*



Medium aperture (moderate depth of field), medium shutter speed (some motion sharp). *A medium aperture (f/4) and shutter speed (1/125 sec) sacrifice some background detail to produce recognizable images of the birds. But the exposure is still too long to show the motion of the birds' wings sharply.*



Large aperture (shallow depth of field), fast shutter speed (motion sharp). *A fast shutter speed (1/500 sec) stops the motion of the pigeons so completely that the flapping wings are frozen. But the wide aperture (f/2) needed gives so little depth of field that the background is now out of focus.*

Choosing a camera will be easier if you first decide what kind of pictures you want to take, then think about which camera design best fits your needs. If your picture taking consists of occasional snapshots, a nonadjustable compact camera may be perfect.

If you are a photography student, a serious amateur, or just someone who would like to learn more about photography, you will want an adjustable camera. For most people this is a digital or 35mm (thirty-five millimeters is the film width) single-lens reflex camera. A camera may have automatic features, but it should also give you the option of manually selecting the focusing distance and either the shutter speed or aperture, preferably both. You also want a camera that accepts interchangeable lenses. Be sure to read about lenses in Chapter 3; lens selection is an important choice.

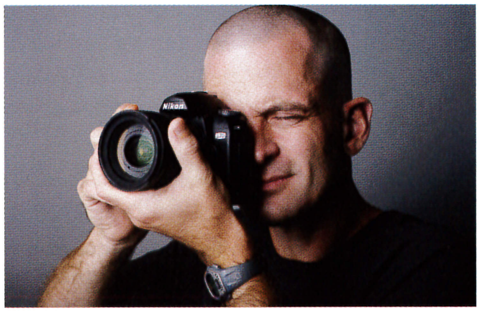
Shop around to compare prices, accessories, and service. Make sure you like the way the camera fits in your hands, and that controls and menus are convenient and easy to manipulate. Find out how to override the automatic features. If you wear glasses, make sure you can see the entire image.

You may be able to find a good used camera at a considerable saving, but look over used equipment carefully. Avoid cameras with abrasions or scratched lenses that could indicate rough treatment. A reputable dealer will exchange a camera, new or used, if your first photographs are unsatisfactory. Examine your first exposures carefully for soft focus, blemishes, or other signs of trouble.

The resolution of the sensor or the size of the film determine the quality of the image the camera produces. One measure of a digital camera's sensor is the number of pixels it captures. All other things being equal, a ten megapixel (MP) camera can make higher-quality pictures than a six megapixel camera. Similarly, the larger the negative, the sharper, smoother, and more detailed any image will be rendered. But the smaller the film format, the smaller the camera can be.

From a 4 x 6-inch print, you probably won't be able to tell whether the image came from six megapixels or twenty-four, or from 35mm or 4 x 5 film. But in a larger print it will be obvious; the bigger the print, the more the difference. See page 157 for more about resolution.

SINGLE-LENS REFLEX CAMERAS



A single-lens reflex (SLR) camera shows you the scene directly through the lens. You see through the taking lens to focus the scene and compose it exactly. With some cameras you can preview how much of the scene will be sharp, from foreground objects to a distant background. Most SLRs have a digital sensor (digital SLR is abbreviated DSLR or D-SLR) or use 35mm film.

The viewing system is built around a mirror. While viewing, light coming through the lens is reflected by this mirror up to a viewing screen, then to a five-sided pentaprism that turns the inverted image around so it appears the correct way to the eye (diagram above right, left image). The aperture is held wide open (so you can focus using a bright viewfinder image) until the moment of exposure, so you will only see depth of field accurately if you are shooting at the maximum aperture. But otherwise, the image produced is the same as the image viewed through the lens. When the shutter is released, the mirror first swings up, permitting light to reach the shutter, which opens to reveal the light-sensitive surface at the back of the camera (diagram above right, right image).

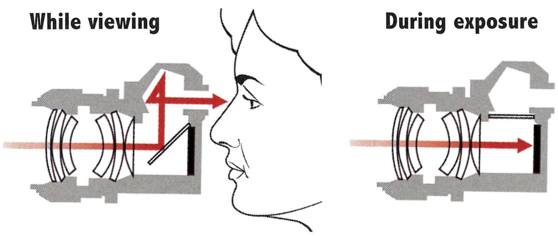
Advantages: Because the viewing system uses the camera lens itself, it works well with all lenses from wide angle to super telephoto; whatever the lens sees, you see—and that is what will be recorded. This is especially useful for close-ups; unlike Rangefinder/Viewfinder cameras (opposite) there is no parallax error. DSLRs usually have larger sensors than compact digital cameras, and capture higher quality images with less noise (page 83).

Disadvantages: A single-lens reflex is heavier and larger, and usually more expensive, than a compact camera. An SLR is relatively complex, with more components that can fail. Its moving mirror makes a clack during exposure, very loud in the medium-format models; this is a drawback if you are stalking wild animals or self-conscious people. When the mirror moves up for exposure, it momentarily blacks out the viewing image, and the motion of the mirror and shutter causes vibrations that can cause some blur at slow shutter speeds.

Choosing a camera: Single-lens reflex cameras are the most popular when a buyer moves beyond snapshot level. SLRs offer a great variety of interchangeable lenses and accessories, plus features such as built-in flash.

Automatic features abound: automatic exposure, focus, and flash are often standard; some can be fired in rapid bursts. Be careful not to pay extra for something you might use only once in a while.

Make sure the camera allows you to manually override automatic features when you want to make exposure and focus choices yourself. And consider how convenient it is to select or override those automatic features. Does the camera have easy-to-adjust, conveniently located knobs and dials or tiny, difficult-to-access buttons, and hard-to-read menus?



Medium-format single-lens reflex cameras are popular with photographers who are willing to pay a premium for a higher-quality image without losing the versatility of a single-lens reflex. Not only are lenses interchangeable, but the camera's back is too; you can expose part of a roll of black-and-white film, remove the back, and replace it with one loaded with color film or with one (above) for highly-detailed digital capture. Sensors and film frames vary in shape and size; film backs can be 6 x 6cm (2 1/4-inch square), 6 x 7cm (2 1/4 x 2 3/4 in.) or 6 x 4.5cm (2 1/4 x 1 5/8 in.)

TWIN-LENS REFLEX CAMERAS

Twin-lens reflex (TLR) cameras use only film, usually 6 x 6cm ($2^1/_4$ inches square). With most models, lenses are not interchangeable, and few models are currently manufactured. But TLRs are quiet, and generally less expensive than other types of medium-format cameras. Finding an inexpensive, used TLR is a good way to experiment with larger-format film.

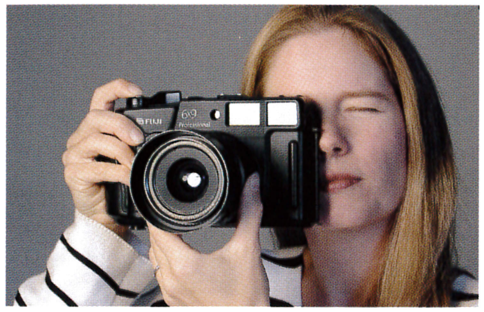
RANGEFINDER/VIEWFINDER CAMERAS

A viewfinder camera shows you the scene through a small window (the viewfinder). The viewfinder is equipped with a simple lens system that shows an almost—but not quite—exact view of what the picture will be. Many inexpensive cameras (called "point-and-shoot" have a viewfinder plus automatic focus.

A rangefinder camera has a viewfinder, plus a coupled rangefinder that lets you focus the camera manually as you view the scene. Some compact digital camers (see below) incorporate a viewfinder, but many rangefinder and viewfinder cameras use 35mm film. A few, like the one at right, use larger 120 roll film.

Advantages: The camera is compact, lightweight, and fast handling. Compared to a single-lens reflex camera, it has few parts that move during an exposure, so it is quieter and less subject to vibration during operation. A high-quality rangefinder camera has a bright viewfinder image, which makes it easy to focus quickly, particularly at low light levels where other viewing systems may be dim. Wide-angle lenses are likely to be sharper than those made for reflex cameras because short lenses for reflex cameras need a more complex design to provide clearance for the reflex mirror.

Disadvantages: Because the viewfinder is in a different position than the lens that exposes the negative, the



camera suffers from an inherent defect called parallax that prevents you from seeing exactly what the lens sees. The closer a subject is to the camera, the more evident the parallax. Better cameras correct, to some extent, for parallax but a viewfinder camera is a poor choice for close-up work.

Choosing a camera: A rangefinder camera with adjustable controls gives you more flexibility than a simple point-and-shoot film model. You focus and set the exposure yourself, or with some models have the option to do so automatically. Medium-format rangefinder cameras combine large film with a compact design. A high-quality 35mm rangefinder camera has long been a favorite of experienced photographers who value the camera's dependability and its fast and precise focusing.

COMPACT DIGITAL CAMERAS

Compact digital cameras, like digital SLRs, generate photographs by focusing the light rays of a scene through a lens onto a sensor—an array of light-sensitive diodes. The sensor converts the image to data that is transferred to a memory card in the camera. Some compact cameras—the more expensive ones—rival DSLRs in picture quality and features, but most are designed for the pockets of tourists and casual snapshooters. Many cell phones are also compact digital cameras.

Advantages: Cameras are available in a wide range of styles, features, and price that can accommodate any individual preferences. Some are made to take the abuse of a rough-and-tumble lifestyle, including operating underwater. Some record short segments of video.

Disadvantages: Some are difficult or impossible to adjust manually and most have a non-interchangeable lens. Many cameras have no viewfinder, so the image must be viewed through a monitor that drains batteries rapidly. There is often a noticeable delay—called shutter lag—between pressing the shutter button and the actual exposure that can cause you to miss peak action. Digital noise (that reduces picture quality) is greater and the ISO range is lower than in DSLR cameras that have a larger sensor. Available accessories are limited.

Compact cameras with professional features are available for more advanced photographers. Many professionals carry a camera like the one at the right as a backup or when they are not on a job. Lenses and sensors are higher quality than in cameras intended for the pockets of amateurs, and they can usually deliver files in a raw format (see page 158).

Some designs, like the one at left, are more accurately called "prosumer" than compact since they are only a little smaller than a DSLR. They use a small LCD monitor to provide a viewfinder image; most have a non-interchangeable zoom lens.

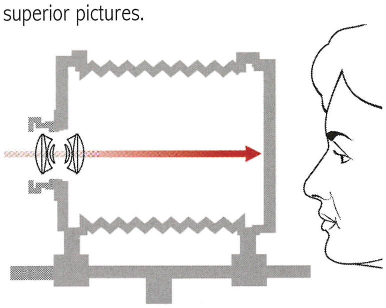
Subcompact digital cameras share the low-priced end of the market with point-and-shoot film cameras. Most are mercilessly nonadjustable: they focus, calculate exposure, and trigger a built-in flash if you need it. Some use a lens with "folding optics" for a thin, flat profile that fits easily in a shirt pocket. Better-quality ones have a good zoom lens and offer some control of focus, exposure, or flash functions. Many take excellent pictures, but they are easy to outgrow as soon as you become more seriously interested in photography.

Choosing a camera: A serious photographer will probably want to have a single-lens reflex. But a serious photograher will also probably have more than one camera. The best camera is always the one you have with you.

VIEW CAMERAS

A view camera has direct, through-the-lens viewing and a large image on a viewing screen. It is the simplest and oldest basic design for a camera. A view camera has a lens at the front, a ground-glass viewing screen at the back, and a flexible bellows in between. You focus by moving the lens or the back forward or back until you see a sharp image on the ground glass.

The view camera is often the camera of choice for architectural photography, fine art, or any use where the photographer's first goal is carefully controlled, technically superior pictures.



Advantages: The image on the ground glass is projected by the picture-taking lens, so what you see is exactly what will be captured; there can be no parallax error (as in a rangefinder camera, previous page) and you can preview the depth of field at the selected aperture. You can examine the large ground glass with a magnifying glass to check sharpness in all parts of the picture. With film, the available sizes are also large (4 x 5, 8 x 10 inches, or larger) and 4 x 5 digital backs capture a larger area in greater detail than any other digital camera. You can change the position of lens and back relative to each other so that you can more precisely control focus or perspective. When using film, each picture is exposed on a separate sheet, so you can give negatives individual development.

In a view camera, the light comes through the lens, directly to a ground-glass viewing screen. *The image you see is upside down. As an aid in composing and aligning your subject, the ground glass may be etched with a square grid.*

Disadvantages: The cameras are bulky and heavy, and almost all require using a tripod. They are slow to use. You must set up and focus first, then insert the film or digital back to make the exposure. The image projected on the ground glass comes directly from the lens, so it is upside-down and can be dim. To see it clearly you must put a focusing cloth over both your head and the back of the camera. Learn more about the view camera in Chapter 15.

BRIAN ULRICH
Six Flags Mall, Dallas, Texas, 2009

A view camera can capture extremely high-definition images, *in this case on 8 x 10-inch color-negative film from which Ulrich makes 48 x 60 inch exhibition prints. He used a tripod (opposite page) so there was no camera movement during the half-hour-long exposure. Using a police lamp plugged into his car's lighter socket, he illuminated the building by moving the beam over selected parts of the building and setting.*

This image is part of the Dark Stores *series, Ulrich's response to demographic and economic shifts that leave stores, shopping centers, and malls vacant and forlorn. He says "the futility of a retail-based economy reveals itself clearly in the empty malls and retail stores that are reminders of consumption without foresight."*

Tripod

Monopod

Tabletop tripod

To hand hold a camera, support the camera from underneath with your left hand. *The right hand presses the shutter and operates controls. Press both arms against your body, relax, breathe out, and squeeze the shutter release gently to avoid jerking the camera.*

With the camera held vertically, *the left or right hand can support the camera. Keep that arm against your body to steady the camera.*

With a long lens or at a relatively slow shutter speed without a tripod, *try to find some extra support such as a stool, chair, or other object to brace yourself against.*

A tripod provides the steadiest support for a camera. *It is essential for slow shutter speeds. Some tripods have a center shaft that can be removed and reversed; the tripod head and camera can then hang upside down so the camera can be brought very low to the ground. A cable release lets you trigger the shutter without jarring the camera. Leave a little slack in the cable instead of pulling it taut.*

MINIMUM SHUTTER SPEEDS FOR HAND HOLDING A 35MM OR DIGITAL SLR CAMERA

Lens Focal Length	Minimum Shutter Speed
24–28mm	1/30 sec
35–50mm	1/60 sec
85–100mm	1/125 sec
135–200mm	1/250 sec
300mm	1/500 sec
600mm	1/1000 sec

Keep the camera steady during an exposure. Even with the finest camera and lens, you won't be happy with the pictures you take if you don't keep the camera steady enough during the exposure. Too much camera motion during exposure will cause sharpness problems ranging from slight image softness to hopeless blurring.

How much camera movement is too much? That depends on several factors, including how large the image will be. Any blur is more noticeable when viewed closely or in a big print. The camera's design affects how much it moves during an exposure; SLRs are particularly prone to vibration. The slower the shutter speed, the more you have to worry about camera movement. The longer the focal length of the lens, the more movement becomes apparent. Longer lenses magnify objects on the film—and camera movement too.

If you are hand holding a camera, use a shutter speed faster than the focal length of the lens: for example, 1/250 second or faster with a 200mm lens (see chart below left). Press the shutter release gently and smoothly. If you can, brace your body in some way by leaning your back against a wall or your elbows on a table, fence, or other support.

Using a tripod and cable release is the best way to prevent camera movement. The tripod should be sturdy enough for the camera; if you balance a large, heavy camera on a flimsy, lightweight tripod, your camera can end up on the floor. On the other hand, if your tripod isn't very heavy, you are more likely to make a habit of carrying and using it. When making portraits, putting the camera on a tripod lets you take your eye away from the viewfinder and establish more rapport with your subject.

Tabletop tripods are sometimes useful; their very short legs can be steadied on a table or car hood or even against a wall. A monopod, a single-leg support, gives extra stability if you have to keep moving, for example, along a football sideline.

Image stabilization (or "anti-shake") helps a lot. Some digital cameras move their sensor and some lenses move an element to let you hand hold a shutter speed up to three stops slower than without it.

photographer at WORK

Photojournalist James Nachtwey

James Nachtwey's gentle manner and voice belie the violence and heartache he has recorded. A contract photographer for *Time* magazine, Nachtwey is one of the best-known and most widely respected photojournalists. He has covered wars and civil strife in El Salvador, Nicaragua, Lebanon, Sri Lanka, Afghanistan, Chechnya, Northern Ireland, Rwanda, South Africa, the West Bank and Gaza, Bosnia, Kosovo, and Iraq.

Nachtwey taught himself photography, then began his career with four years on a newspaper. Black Star, a photo agency, helped him get assignments and publish pictures when he started freelancing. In 1986 he joined Magnum, the respected photo cooperative, leaving to form the VII Photo Agency in 2001.

When arriving in a war zone, Nachtwey says, he first establishes a logistical base. This includes transport, communication (often involving an interpreter), and a place to stay. Lodging might be a hotel, a room with a local family, the floor of an abandoned bombed-out building, or a sleeping bag or blanket on the ground. If possible, he contacts a local newspaper or one of the international wire services to orient himself to the ongoing situation.

When photographing in tumultuous situations, Nachtwey uses patience and common sense. "Many photographers rush their images," says Robert Stevens, Nachtwey's former editor at *Time*. "They arrive, see a subject in front of them, and start shooting. They often think they have recorded what is important in a few moments, but they haven't. It's important to take time and wait. Jim waits and waits until the time is right."

Many photographers forget about the background, Stevens explains, and end up with images where the background distracts from the most important part of the photo. Using a Canon digital (or sometimes film) SLR camera and a zoom lens, Nachtwey frames his photos in a deliberate but fast way, by shifting his body up or down, right or left to get elements the way he wants them. He can upload his pictures by telephone directly to *Time* but, when he can, edits his pictures before they are sent.

Nachtwey works on the front lines, but he avoids reckless behavior. "I try to be aware of the changing dynamics of whatever situation I am in," he says. "I make split-second decisions, based on a combination of intuition and experience, calculated to enable me to do an effective job and survive. In the riskiest situations, I usually work alone, but sometimes with another, trusted colleague."

Emotional strength can be as critical as technique or tactics. How does he continue photographing while witnessing horror? "If you go with a camera to places where people are experiencing a great tragedy, you have a responsibility," he told one interviewer. "The value of the work is to make an appeal to the rest of the world, to create an impetus for change through public opinion. Public opinion is created through awareness. My job is to make people aware."

"I used to call myself a war photographer," he says. "Now I consider myself an antiwar photographer."

JAMES NACHTWEY "Ethnic cleansing" in Mostar, Bosnia, 1993

"Nachtwey's photographs are always clean and striking compositions. . . . because he is honest and clear in his stance," *writes historian Luc Sante. The photographer sees images such as this one of a Croat militiaman firing on his Muslim neighbors "as a visualization of the kind of hell on earth that can be created by human beings for human beings."*

DAVID TURNLEY Nachtwey Under Fire, 1994

Photojournalist James Nachtwey takes the front line during a gun battle in South Africa. *According to writer David Friend, fellow journalists say Nachtwey borders on being invincible under fire, almost as if shielded by a force field.*

JAMES NACHTWEY Nicaragua, 1982

Nachtwey covers conflicts as they take place but also shows their impact on people's lives. *For a Nicaraguan child, an abandoned tank provides a playground.*

JULIE ANAND
Water Lenses, 2003
The simple lens formed by a water-filled fishbowl inverts an image exactly the way your camera's more complex lens does. *Anand uses the device to comment on water use in America's arid southwest.*