CHAPTER

10

The Lens

THE CAMERA LENS

The lens of a camera is often likened to the human eye—in fact, many people have announced that "the lens is the eye of the camera." This is true, in that light enters through and is controlled by the lens and ultimately this light registers an image. However, there are many things that human eyes and human psychology of perception do automatically, which, on a lens, must be accomplished manually. Framing, focusing, and exposure are activities we rarely consciously think about with respect to the function of our eyes, but on a lens, which relies on us to deliberately set each of these functions, we are presented with a range of possibilities. Every lens-related variable offers not just a function, but also an array of creative choices. These choices are, in fact, part of the creative potential of any lens and part of the aesthetic palette of a filmmaker. Often there is no absolute "right" setting; rather, you must find the appropriate setting for what you want to express. In film or video production, registering an image is not done in the blink of an eye. Focus doesn't just happen; we must ask, "Where do we want our focus to be?" There is more to creating a powerful image than simply allowing enough light to see the subject clearly. We get to decide how much light we want and exactly how bright or dark, clear or obscured our subject will appear. On every shot we must decide, from a wide range of possibilities, the size of the subject and the visual perspective within the frame. Knowing how lenses work will help you choose the right lens and settings to express exactly what you need them to say to your audience. It is helpful to remember that the lens is much more than just the eye of the camera: it becomes the eyes of your audience.

Whether you are shooting on digital video, 16mm film, or 35mm film, the basic construction and function of the camera lens are the same. All light entering the camera comes in through the lens, and this light must be carefully controlled in order to achieve a usable and expressive image.

Broadly speaking, lenses are a series of polished glass sections called **lens elements.** These elements are held parallel to each other in a light-tight housing called the **barrel**, or **lens housing.** The function of these glass elements is to gather the light reflecting off a scene and, through optical refraction, direct that light precisely onto the camera's focal plane. The **focal plane** (also called **film plane**) of a film camera is the emulsion of the film, and every film camera has an external marking that indicates precisely where the film is located. The film plane marking looks like this: ϕ. The focal plane of a video camera is the **faceplate** of the CCD chip. In video cameras with three chips, there are three focal planes, all calibrated to exactly the same distance from the last element of the lens. The lens gathers light reflecting off a three-dimensional scene and projects it as a two-dimensional image onto the focal plane. The image registered on the focal plane is both reversed and flipped (Figure 10-1). This flipping of the image occurs at the exact optical center of the lens and is later reversed in the projection (film) or scanning process (video).

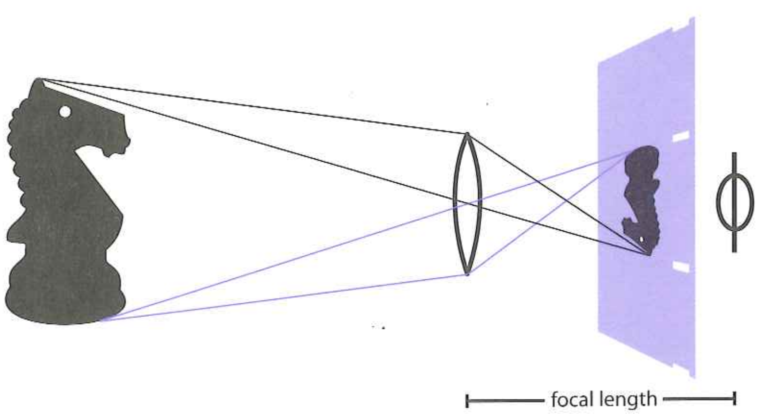


Figure 10-1 Simple image formation by a lens. A lens gathers incoming light and focuses it on the film plane. At the optical center, the image is not only flipped, but also reversed.

The type, placement, and number of glass elements in any given lens vary widely depending on the function, quality, and perspective attributes of the lens. There are many lenses to choose from, so understanding lenses in general will help you pick the right one to create the image you want.

Focal Length

The **focal length** of a lens determines the degree of magnification or de-magnification of the scene being shot. Different lenses offer different focal lengths. Focal length is determined by the distance between the **optical center** of the lens (the point at which the image flips) and the focal plane, ϕ. This distance is usually measured in millimeters (25mm, 75mm, 150mm, etc.), although older lenses may be marked in inches. The focal length of a lens affects both the image size within the frame and the **angle of view**, which means how much of the scene the lens takes in horizontally (x-axis) and vertically (y-axis).

The longer the focal length, the more the subject is magnified and appears larger and closer to the camera. The shorter the focal length, the smaller the subject is and the farther away objects appear. More specifically, if you double the number of millimeters (say from 50mm to 100mm), you will double the size of the subject in the frame. Also, the longer the focal length, the narrower the angle of view becomes and vice versa. There are three broad focal length classifications for lenses: **wide angle** (short lenses), **normal** (medium lenses), and **telephoto** (long lenses) (Figure 10-2).

A **normal lens** approximates the same perspective and image size that the human eye would see if one were to stand in the same spot as the camera (not including peripheral vision). Although this sounds like a fairly nonscientific description of a normal lens, human visual perspective is indeed the intended reference point. The actual focal length of a normal lens is primarily determined by the size of the imaging format you are using. For the 16mm film format, the focal length for a normal lens is 25mm. For the 35mm film format, a normal lens is 50mm. In video, the normal lens length for a ⅔″ CCD is 20mm, for a ½″ CCD it is 15mm, for a ⅓″ CCD it is 11mm, and for a ¼″ CCD it is 8mm. As you can see, the larger the area of the imaging device, the longer the focal length is for a normal lens.

Wide-angle lenses are those with focal lengths shorter than normal lenses. Wide-angle lenses reduce the size of the image and broaden the angle of view, compared to the perspective of the human eye. In the 16mm film format, a 15mm lens is considered slightly wide angle, a 10mm lens is wide angle, and an 8mm lens very wide angle. An extreme wide-angle lens, with an angle of view greater than 180°(!), is also called a fisheye lens.

Given the small size of most consumer and "prosumer" video imaging devices, which makes for a very short normal lens, it's difficult to find a video camera with an extreme wide-angle end to their lens. However, most camera manufacturers offer a wide-angle lens attachment as an optional purchase. This is, in effect, another lens that attaches to the camera's existing lens and allows for extreme wide-angle shots.

Lenses that have a longer focal length than normal and that enlarge the size of the image and narrow the angle of view are called **telephoto lenses.** In the 16mm film format, a 75mm lens is slightly telephoto, a 120mm lens is telephoto, and a 250mm lens is very telephoto. The exact focal length of a lens can be found etched into the front of the lens barrel.

■ **Figure 10-2** Prime lenses have a fixed focal length, and can be easily identified by reading the engravings on their barrels.

Lens Perspective

Perspective is one of the most important considerations when we think about framing and composition. Perspective is essentially a combination of the angle of view, in terms of both the **horizontal dimension** (**x-axis**) and the **vertical dimension** of the frame (**y-axis**), and the depth relationship (near versus far) between objects. This **depth dimension** is the **z-axis**, and because a film image is two dimensional, the sense of depth is an illusion created by the composition of the frame. We have already discussed creating deep frames and flat frames through mise-en-scène in Chapter 3 ("Shot Composition and the Graphic Qualities of the Frame"), but how does lens choice actually affect perspective?

When we set up a shot, we often first consider the size of the framing (e.g., long shot, medium shot, close-up), which determines the size of the subject in the frame. How we achieve that specific framing (say a medium shot) can be accomplished with any number of different lenses, and this choice has a profound effect on all the perspective dimensions in the frame.

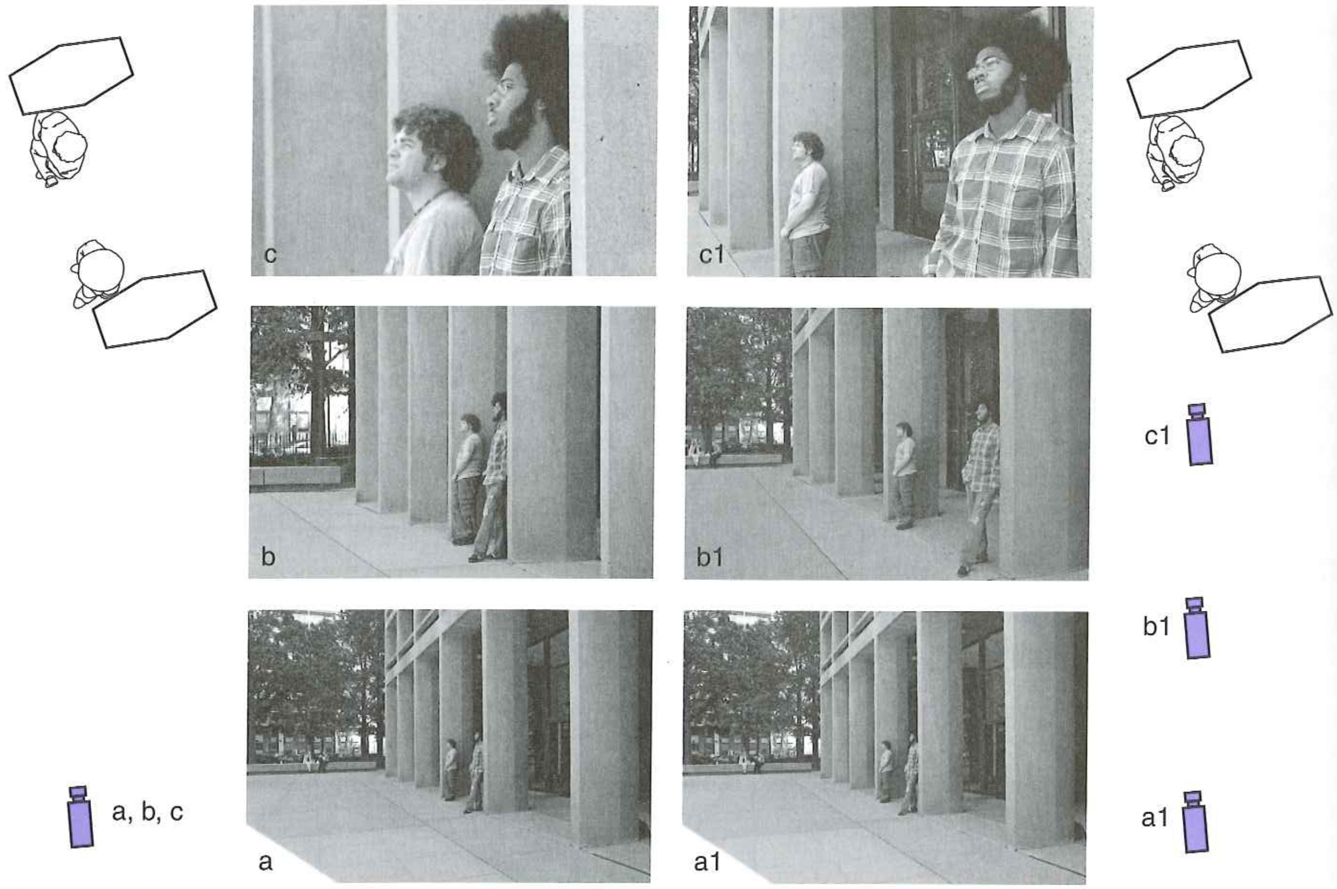
X-axis and Y-axis Field of View

There are two ways to affect the size of a subject in the frame. The first is to change the camera-to-subject distance—moving the camera itself closer or farther from the subject. The other is to alter the magnification of the scene by changing the focal length of the lens you use. There are significant compositional differences between these two options. First, let's consider the x-axis and y-axis differences. When you change only the camera-to-subject distance, the subject indeed gets larger or smaller, but you maintain the same horizontal (x-axis) and vertical (y-axis) vista - called the **field of view** (or **angle of view**). However, leaving the camera stationary and changing focal length (longer or shorter) to change the size of the subject in the frame alters the field of view, narrower or wider. This significantly changes the amount of background information contained in the frame. Compare the two long shot examples (photos b and b1) from Figure 10-3. The subjects in both shots are nearly identical in size, and the horizontal center of both frames is the same (no left-to-right angle adjustment); however, the shot taken with the wide-angle lens and camera moved closer (shot b1) includes the two women talking (to the left of the frame), and the shot taken by leaving the camera stationary and using a longer focal length (shot b) has narrowed the field of view to exclude them. Notice also how much more we see of the space above and below the two subjects in the wide angle/close camera frame (shot b1).

Y-axis and Depth

The other perspective dimension that is important to consider is that of the perception of depth, or relative distances of objects along the z-axis. A normal lens replicates the same perception of depth that our eyes see. For example, if we use a normal lens to frame a subject in a medium shot with another object five feet behind, that object will indeed seem like it is five feet behind the subject in the shot.

Wide-angle lenses tend to exaggerate the depth along the z-axis, especially when close to the subject. The space between objects appears to be greater because of the relative distances between the camera and the objects along the z-axis. For example, look at the three images taken with a wide-angle lens and moving the camera (Figure 10-3, a1, b1, and c1). The two subjects are, in reality, about six feet apart and the z-axis perspective in shot a1 doesn't seem exaggerated; but as we move closer with the wide-angle lens (b1 and c1), the distance between them seems to grow wider and wider. This is because the distance between the subjects, relative to the distance of the camera to the foreground subject, becomes greater. Put another way, the distance between the camera and foreground subject is much shorter than the distance between that subject and the background objects (background guy and other pillars). In shot c1, the camera is only about a foot and a half away from the guy in the foreground, making the distance between the subjects four times greater, causing these objects to appear far from each other. The more



■ **Figure 10-3** Changing focal length versus moving the camera to achieve a specific shot size has a significant impact on the field of view and the perspective of the image *(left)*. Three frames from a stationary camera (wide angle (a); normal (b); telephoto (c), *left*). Three frames taken by moving the camera (all wide angle) *(right)*. (See this as a high resolution and interactive example online.)

wide angle our lens, the more it will exaggerate depth in this way. Wide-angle lenses are often used to exaggerate, for example, the space between a person (near foreground) and a destination (background), to stress the idea that they have a long way ahead of them before reaching their destination.

The converse is true for telephoto lenses, which have the effect of compressing space along the z-axis. Look at the shots a, b, and c in Figure 10-3 as we increase the magnification (the focal length) of the scene from the stationary camera. As the focal length increases, it appears as if the depth distance between the two subjects (and pillars) collapses. The more telephoto the lens, the more compressed the z-axis distance. We have all seen shots of a character walking among the crowds on a city sidewalk. It looks as though there is no space at all between all these people; the crowd looks like it's packed so dense that it seems they are practically walking on top of each other. This is accomplished with a very long lens, shooting from a long distance, with the depth compression effect suggesting a feeling of claustrophobia and congestion.

Now compare shots b with b1, and c with c1 in Figure 10-3. Even though the shots are more or less the same size (long shot and medium shot, respectively) there is a big difference in the perception of horizontal, vertical field of view and the perspective of depth, creating an entirely different look and feel to the shots. The famous dolly/zoom from Martin Scorcese's *Goodfellas* (1990) perfectly illustrates this lens phenomenon in one single shot (Figure 10-4). A **dolly/zoom shot** involves changing the camera-to-subject distance with a dolly while simultaneously changing the focal length to maintain the same framing. In the case of the *Goodfellas* diner scene, the dolly was pulled away from the subjects while the focal length was adjusted increasingly telephoto to maintain

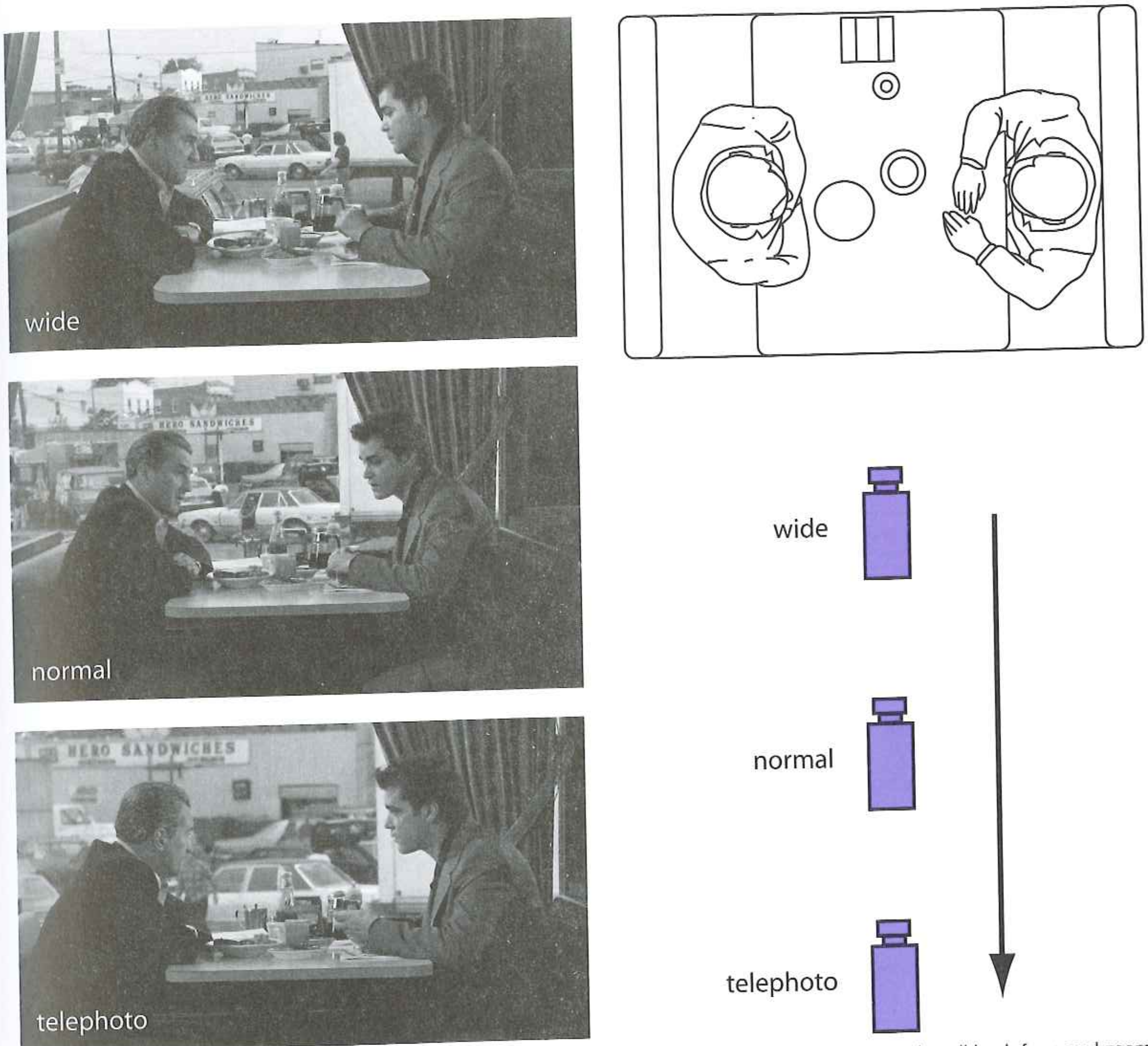


Figure 10-4 This single shot from *Goodfellas* used a dolly move and a zoom lens to simultaneously pull back from and zoom in to a conversation between Jimmy (Robert De Niro) and Henry (Ray Liotta). This technique effectively keeps the subjects the same size in the frame but creates substantial spatial distortion in the background, which, in this case, vividly reflects Henry's unsettled mental state.

in practice

Understanding how the perception of depth can be manipulated with lenses is certainly vital to creating dynamic compositions, but one must also understand the narrative context of the scene or shot in order to utilize their expressive potential in appropriate ways.

Terry Gilliam is known for being a "short lens director" for his frequent use of wide-angle lenses, which is an essential part of his unique visual sensibility. In general he is keen on exposing as much of the location and art direction as possible, and wide lenses are the best option for this, given their wide field of view and deep focus capabilities. However, sometimes Gilliam will pull out an extra wide-angle lens to infuse a scene with a very particular emotion. In *The Fisher King* (1991) (photographed by Roger Pratt), the protagonist Jack Lucas, in an effort to heal his comatose friend Parry, attempts to steal what Parry believes to be the true "holy grail." In fact, the object is merely a worthless trophy cup in a rich person's house. In the scene in which Jack, who is clearly not an experienced thief, must climb a rope to get onto the roof of the rich man's "castle," Gilliam uses an extreme wide-angle lens from above and below to exaggerate the sense of height and depth and therefore the sense of mortal danger. These shots convey a strong sense of vertigo, which Jack himself must be feeling—since it looks like it's is a long, long way to the pavement should he fall.

Similarly in Steven Zaillian's *Searching for Bobby Fischer* (1993) (cinematography by Conrad Hall), in the climactic scene in which the protagonist Josh in practice

plays a fearsome opponent in a children's chess tournament, a wide-angle lens is used to exaggerate the space that Josh must walk in order to reach the chess table. The wide-angle of view also reveals a gauntlet of other players watching his progress to the head table. His apprehension and nervousness in the scene is conveyed by the wide angle lens because it feels to the viewer (as it must to him) that this is the longest walk of his life (**Figure 10-5**).

On the other end of the scale are telephoto lenses, which are used to collapse space. Ramin Bahrani calls *Man Push Cart* (2005) a "long lens" film, meaning that it was shot primarily with telephoto focal lengths. *Man Push Cart* is the story of Ahmad, a Pakistani immigrant in New York City who is trying to start a new life for himself and his son. His main hope for survival is the tiny food cart that he rents. By shooting with a telephoto lens, Bahrani and cinematographer Michael Simmonds were able to create an overall sense of the packed and claustrophobic environment of New York City. The telephoto lens is used to particularly harrowing advantage in the scenes in which Ahmad pulls his food cart along the roadside to get to his spot early in the morning. The dangers of his morning routine are viscerally communicated in these scenes, which are shot with a telephoto lens from some distance, greatly compressing the space between Ahmad and the huge trucks bearing down on him from all sides.

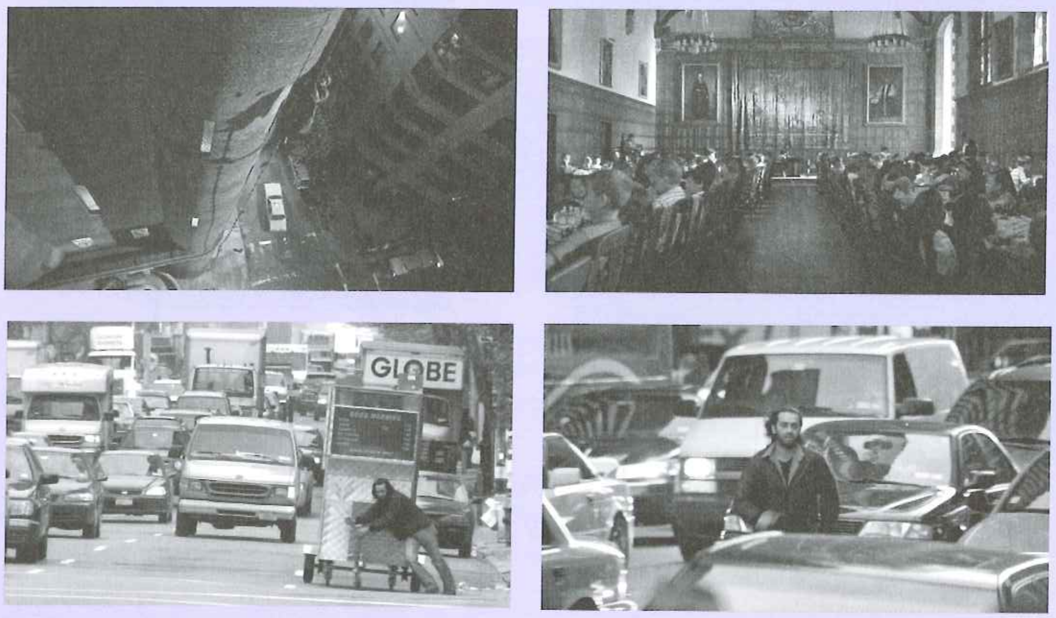
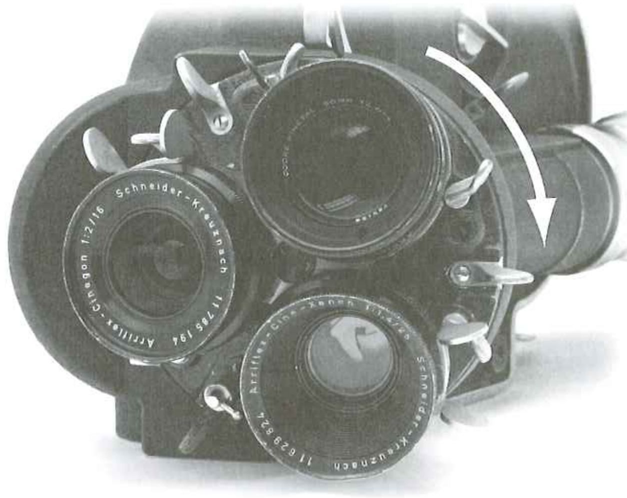


Figure 10-5 Perspective can be manipulated for dramatic effect by carefully selecting the focal length of your lens. Wide-angle lens shots from Gilliam's *The Fisher King* (1991, *top left*) and Zaillian's *Searching for Bobby Fischer* (1993, *top right*) and two shots taken with a telephoto lens from Bahrani's *Man Push Cart* (2005, *bottom*).

the same subject size. The result is that the background loses some of its horizontal and vertical field of view (notice the cars and buildings) and it also appears to be drawing closer and closer to the subjects.

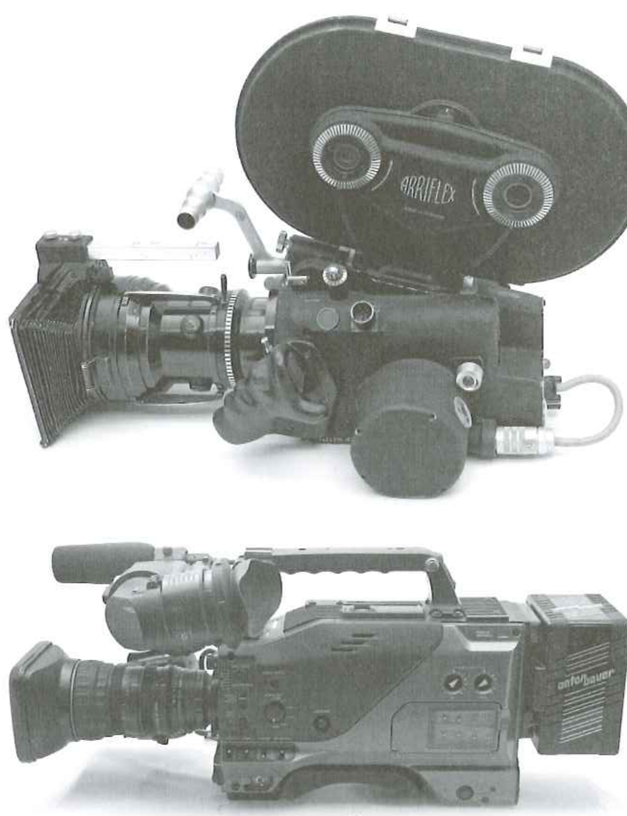
Prime and Zoom Lenses

Lenses that have one fixed focal length are called **prime lenses.** These lenses are very common in film production. Many cinematographers favor prime lenses because their simple design allows them to be made with few glass lens elements, which means that there is less chance for loss of light or lens aberrations to occur (see "Lens Speed" section). However, if you are using primes lenses and decide to change the focal length of a lens from one shot to the next (say change from a 25mm lens to a 120mm lens in order to get in closer to the subject without moving he camera), then you need to change your lens. With prime lenses, you need to change the lens every time you want a new focal length. For this reason, many 16mm cameras are built with a rotating turret (**Figure 10-6**). This turret has three lens mounts and will accommodate three prime lenses of various focal lengths. The three lenses mounted on a lens turret usually consist of one normal lens, one telephoto lens, and one wide-angle lens. Turrets allow you to switch between lenses by simply rotating and positioning the desired lens in front of the gate. **Zoom lenses**, which are also referred to as **variable focal length lenses**, offer precisely that—a continuous range of focal lengths in one lens housing. Zoom lenses are constructed with movable lens elements that slide forward and backward to physically shift the optical center and therefore change the focal length of the lens. **Zooming in** means adjusting the optical center away from the focal plane and therefore increasing the magnification power of the lens (telephoto), and **zooming out** means adjusting the optical center back toward the focal plane, causing the image to become more wide angle. Zooming is accomplished with the adjustable **zoom ring**, calibrated in millimeters, which allows the filmmaker to manually set the desired focal length. Some zoom lenses, primarily on video cameras, utilize a servo zoom motor, so that you can glide from one focal length to another smoothly during a shot (Figures 10-7 and 10-8).



■ **Figure 10-6** Switching between prime lenses is a simple task when they are mounted on a rotating turret, like the lenses on the Arri-S.

Different zoom lenses offer a different range of focal lengths, and this range is often stated as a ratio (etched into the lens barrel). A 12:1 zoom lens (also stated 12×) is one that increases the focal length 12 times over its full range, and a 10:1 (10×) has a focal length range that increases 10 times. However, the specific range can vary; a 10:1 zoom lens could go from 10mm to 100mm or from 12mm to 120mm. The millimeter range is found on the zoom ring itself (Figure 10-9).

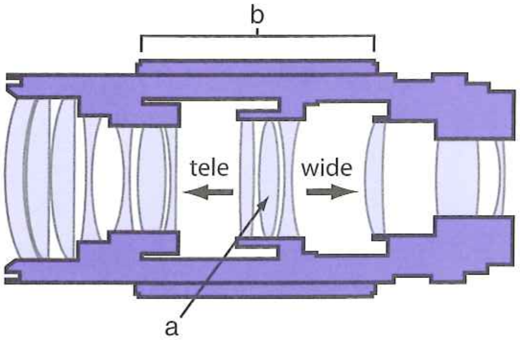


■ **Figure 10-7** Zoom lenses have variable focal lengths and provide great flexibility during shooting at the cost of some quality; they are widely available for film cameras *(top)* and standard on video camcorders *(bottom)*.

Zoom lenses are wonderfully convenient, as they can offer a wide range of focal lengths in one lens; however, there can be trade-offs for this convenience. It requires many more glass elements to make a zoom lens as compared to a prime lens, so zoom lenses are prone to light loss (see "Lens Speed" section) and optical aberrations. Nevertheless, current research and development trends are producing high-quality zoom lenses that are being used by cinematographers who shoot 35mm film for theatrical distribution. Conversely, given the increases in digital video resolution, it's not unusual to see high-end HD cameras fitted with prime lenses in order to achieve maximum image clarity. In fact, there are currently several midlevel DV cameras on the market designed to take prime lenses (see Figure 9-20).

Focus

We all have some sense for what focus is. Images that appear fuzzy and indistinct are "out of focus" and images that are sharply defined and clear are "in focus." But to be more precise about it, **focus** can be generally defined as when a point of light reflecting off the subject is registered as a point of light on the focal plane. The **focus ring** on a lens brings a subject into focus by very precisely moving the front element of the lens forward and backward in relation to the focal plane, which is why the focus ring is always found at the front of the lens.



■ **Figure 10-8** A zoom lens changes focal length by shifting the position of the internal optical center elements (a) by adjusting the zoom ring (b).

■ **Figure 10-9** The focusing ring on a lens has a series of distances engraved in both feet and meters, which are aligned to a witness mark (a) as a reference point. Etched into the zoom ring are the focal length settings in millimeters (b).

What you are adjusting when you move the front lens element is called the **focus point**, or **plane of critical focus**—that is, the precise distance in front of the camera, from the focal plane ϕ, which will be in sharp focus. If you set the focus ring for 5 feet, objects 5 feet from the focal plane will be rendered sharply on the film, and if you set the focus ring to 20 feet, objects 20 feet from the focal plane will be in focus, and so on. Turning the focus ring counter-clockwise moves the plane of critical focus, along the z-axis, away from the camera and vice versa. The range of distances that you find on the focus ring scale will be from the closest to the farthest an object can be and still be brought into focus. This range usually falls somewhere between 3 feet to infinity, which is represented on the focus ring scale with the symbol ∞. The focus adjustment scale is etched on the focus ring and is often in both meters and feet. Be careful not to mix up these scales. Setting the focus is done by turning the focus ring until the distance you want is lined up against a **witness mark**, which is a line etched into a nonmovable part of the lens barrel (Figure 10-9).

When shooting video we can see the actual image that is being registered on the CCD chip, either through the viewfinder or through a larger field monitor, so focusing is usually done by eye. Some video camcorders offer a **focus assist** function, which enlarges a portion of the image to help you find critical focus. In film, we do not see the image being registered on the film; also, as we discussed, many film viewfinder systems involve either a loss of light, a flicker, or a different viewing lens altogether (non-reflex). For this reason, measuring the distance from the focal plane ϕ to the subject with a tape measure is common practice on film shoots (Figure 10-12). Focus has another dimension called depth of field, which will be covered in detail later in this chapter.

in practice

Is there a creative and expressive dimension to focus? Absolutely. What you decide to presented in sharp focus and what you decide should not be in focus can have a huge impact on the narrative content and emotional power of your shots. This scene from the Coen Brothers' film *No Country for Old Men* (**Figure 10-10**, *left*) shows Anton Chigurh *(background)* after he has been apprehended by a west Texas sheriff's deputy *(foreground)*. This is only the second scene in the film and the Coens have been careful not to show us Anton's face yet, so the precise placement of focus on the deputy, who is simply making a phone call, effectively keeps Anton a mystery—though we *can* see enough of him to know he's maneuvering his

■ **Figure 10-10** Focus is carefully controlled to first conceal and then reveal the disturbing features of killer Anton Chigurh (Xavier Bardem) at just the right moment in *No Country for Old Men* (Coen Brothers, 2007).

handcuffs from behind his back to his front and approaching the unaware deputy. Even though we do not know who this character is yet, the choice to obscure his face by keeping him out of focus during this action builds enormous tension, foreboding, and malevolence, so we are not entirely surprised that Anton throttles the deputy with the handcuffs the moment he hangs up the phone. It is not until Anton is well on is way to strangling the deputy to death that we get the first, sharp focus look at the face of Anton Chigurh—the face of a psychopathic killer (Figure 10-10, *right*).

Figure 10-11 In this scene from Alfredson's *Let the Right One In* (2008), maintaining sharp focus exclusively on Oskar's tormentors places us in Oskar's (Kåre Hedebrant) point of view.

In Tomas Alfredson's film *Let the Right One In*, focus point placement is carefully controlled throughout the film to put us in the main character's point of view (Figure 10-11). In this scene, Oskar (foreground with back to us) is in class and is answering a question correctly and quite precociously. Oskar is clearly the central character here, but notice that the sharp focus is placed on the two boys to the left and right of Oskar, as they glare at him. These boys are school bullies who tease Oskar mercilessly. By maintaining the focus on Oskar's tormentors (we never see Oskar's face in this scene), this shot effectively places us in Oskar's point of view; even though he's speaking to the man at the front of the classroom, his mental focus is on the bullies because he knows he has called attention to himself and will now likely be punished for it.

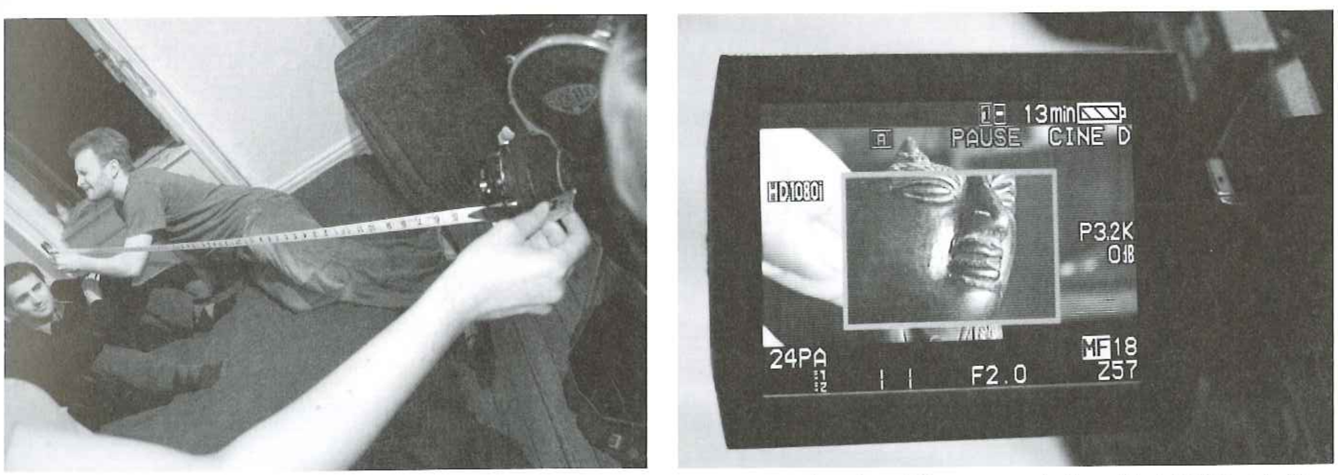
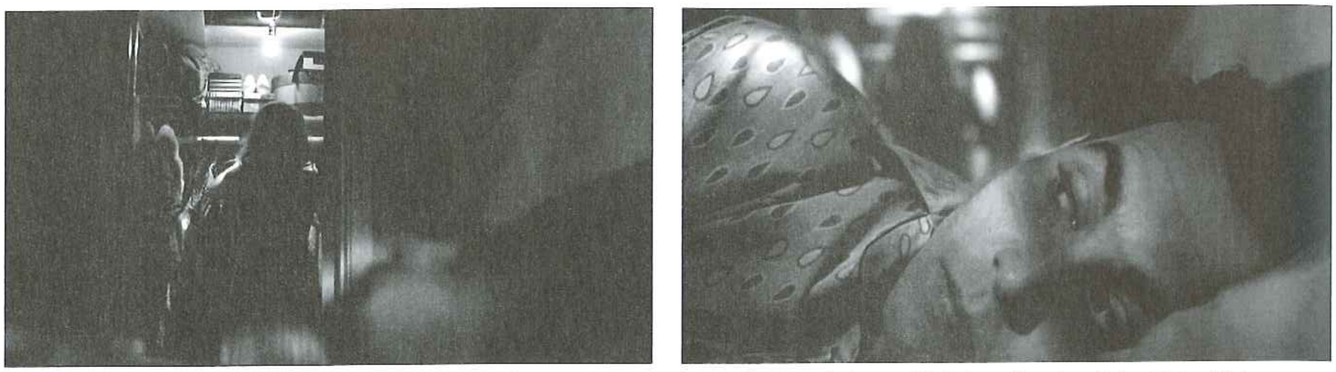


Figure 10-12 Camera-to-subject distance is measured from the film plane engraving, found on all film cameras, to the subject *(left)*. To aid with critical focus, some video cameras offer a focus assist function, which magnifies a portion of the scene *(right)*.

Pulling Focus

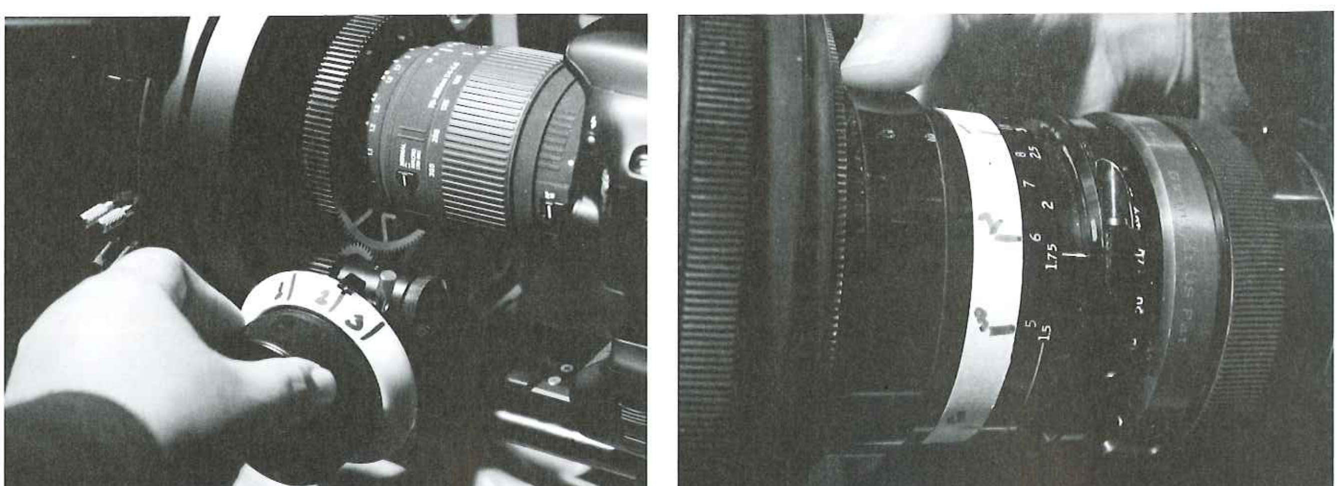
Usually, focus is something you set and leave for the duration of a shot. However, there are times when you may need to change the plane of critical focus during a take, while the camera is running. This is called **pulling focus** and it is common practice in film production. The person who does the actual adjustments to the focus ring is called the **focus puller.** There are two kinds of focus pulling. **Rack focus** means shifting the plane of critical focus between two static subjects along the z-axis. For example, in this shot from Tim Burton's 1994 film *Ed Wood* (Figure 10-13), the focus begins on the background subject Dolores, Ed's girlfriend, as she looks through her closet. When she wonders out loud where her lost angora sweater is, a precisely timed rack focus shifts the visual emphasis to the foreground, and to Ed's knowing reaction, providing a humorous punch line for the scene



■ **Figure 10-13** A perfectly timed rack focus provides humorous punctuation to this scene between Ed (Johnny Depp) and his girlfriend Dolores (Sarah Jessica Parker) in Burton's *Ed Wood* (1994).

because we know he has been secretly wearing his girlfriend's clothes. In these cases, you must find each focus point ahead of time and mark them—either on the focus ring of the lens with paper tape or on a follow focus ring if you have one (Figure 10-14); this allows you to rack focus smoothly and precisely without hunting for focus.

Another type of focus pulling is called **follow focus.** Follow focus is used when your subject is moving along the z-axis either closer to or farther away from the camera, and you must adjust the plane of critical focus to follow your subject's progress. For example, let's say we have a shot in which a subject begins 30 feet away from the camera, then moves to 20 feet away, and finally comes to a rest 10 feet from the focal plane. In this case we need to set marks for both the actor and the focus puller. **Setting marks** means that we place precise markers on the ground for the actor to hit during the course of their movement. You can use tape if the ground is not seen in the shot, but if it is seen, then you need to use something that will not be too obvious, like leaves or twigs. In any case, these marks are set at precise distances. Then, during the take, the focus puller keeps the subject in focus by smoothly following them with the plane of critical focus—hitting the same feet markings on the focus ring when the subject reaches each mark. Follow focus should be done in one smooth movement, not in choppy adjustments, and can require a few rehearsals to get just right (Figure 10-15). (Go to the companion website for video examples of rack and follow focus).



■ **Figure 10-14** A follow focus device *(left)* allows you to mark predetermined focus points for easy focus pulling. If you don't have this device, using paper tape on the barrel of a lens *(right)* can accomplish the same thing.

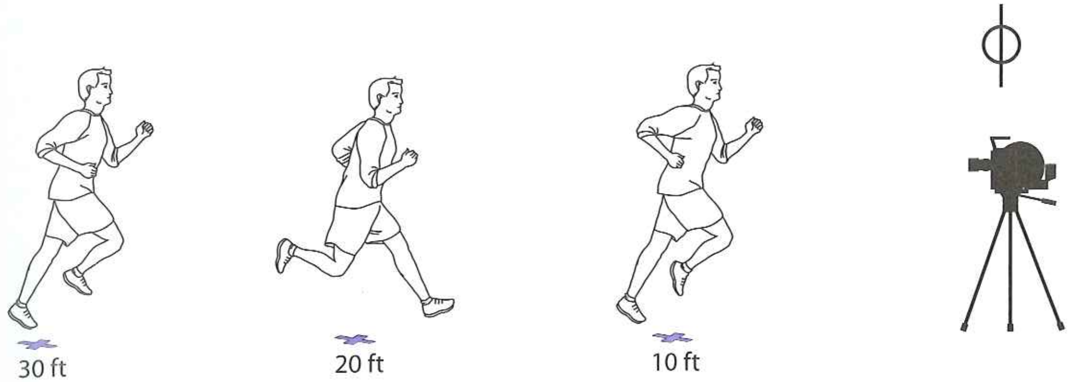


Figure 10-15 Follow focus involves the marking and timing of a subject's movement toward or away from the camera. In this case, a camera assistant will shift the focusing ring as the runner hits predetermined marks on the ground.

Aperture

Another adjustable ring found on all lenses used for film production and on all professional video lenses is the **aperture ring** (or **f-stop ring**). The aperture ring controls a slender disk, a diaphragm, inside the lens called **the iris**, which is made up of flat, matte black, metal blades. These blades overlap in such a way that they create an opening that is nearly circular. This opening is called **the aperture** and all light gathered by the lens must pass through the aperture before it is registered on the film plane or imaging device. By adjusting the aperture ring, the iris either opens (creating a larger aperture opening) to allow more light or closes (smaller aperture opening) to allow less light to reach the film or CCD chip. The size of the aperture opening is calibrated to a scale called the **f-stop scale**, which is etched into the aperture ring.

The F-stop Scale: f/1.4, f/2, f/2.8, f/4, f/5.6, f/8, f/11, f/16, f/22

At first, f-stops can be a little confusing because the smaller the f-stop number, the larger the aperture opening is and the more light is allowed to reach the imaging device. Conversely, the smaller the f-stop number, the larger the aperture opening is and the more light is allowed through the lens. So f/2 lets in more light than f/11. This inversion occurs because the f-stop scale is arrived at by dividing the focal length by the diameter of the aperture opening (Figure 10-16). As a filmmaker you don't need to worry too much about *how* this scale was derived; you do, however, need to understand the relationship between this scale and how it corresponds to the amount of light passing through the lens and exposing your film.

Each number on the scale is called a **stop.** We say, there is one stop between f/4 and f/5.6 and two stops between f/4 and f/2. The difference of one stop has the effect of doubling or halving the amount of light allowed to pass. Expanding the aperture (smaller numbers) is called **"opening up."** Reducing the size of the aperture (bigger numbers) is called **"closing down"** or **"stopping down."** Opening up to f/4 from f/5.6 allows in twice as much light. Closing the aperture to f/2.8 from f/2 cuts the light in half. Each stop, open or closed, doubles or halves the previous number, so that if we open up one stop we double the light (×2); if we open up another stop it is doubled again 2 × 2 (four times more light); if we open up a third stop we get 2 × 2 × 2 (eight times more light), and so on (Figure 10-17).

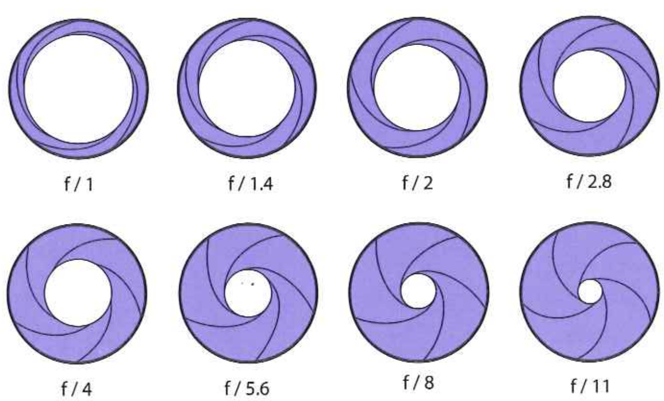


Figure 10-16 As the f-stop number grows larger, the aperture opening grows smaller, and vice versa.

Iris

The iris is actually a simple device, but it plays an enormous role in film production. Obviously the simplest application of the iris is to control the amount of light

Figure 10-17 Both film and high-end video lenses have engraved aperture f-stops for precise control over the incoming light.

exposing the film, or striking the CCD, in order to give us an "acceptable" image. Allow too much light through the lens and we will have a washed out, overexposed image; block too much light and we will have a dark, underexposed image. This is why it is easy to believe that there is one "right" exposure for a scene, but nothing could be further from the truth. The interrelationship between the illumination intensities of a given scene and the selection of your f-stop is a central factor in determining the look, tone, mood, and visual content of each and every shot. For any given scene, there may be a range of f-stops that will give us an "acceptable" image, but each different setting can inflect the image in various ways. With more than one option, the decision always boils down to the questions: What do you want to communicate with this shot, and which f-stop will create the image that best expresses your idea? In fact, understanding apertures and exposures is so essential to the filmmaker's creative palette that I have dedicated two chapters later in the book to this topic. (See Chapters 12 and 14.)

Lens Speed

The ability of a lens to gather light is determined by the largest possible f-stop of that particular lens. We refer to this ability as **lens speed.** A **fast lens** can open up to allow more light than a **slow lens.** The larger the maximum aperture can be, the faster the lens is. What limits the ability of a lens to gather light are the optics—the number and quality of the glass elements. For this reason, it is usually the case that wide-angle lenses are faster than telephoto lenses (they use fewer elements). A lens with a maximum aperture of f/1.4 is a very fast lens and can register a readable image with very little light. Zoom lenses tend to be much slower, as their construction requires many more elements. A lens speed of only f/3.5 is not uncommon for a zoom lens. The maximum f-stop number is usually etched into the front of the lens barrel and can sometimes fall between the usual numbers found on an f-stop scale.

T-stops

As we have seen, the f-stop scale is devised through a mathematical formula. This formula, however, assumes a lens with perfect optics; meaning that 100% of the light is transmitted through the lens without any light loss. In effect, f-stops are a theoretical number because no lens has absolutely perfect optics. This can present an inaccuracy in exposure, as many lenses lose quite a bit of light, some as much as one full stop! To remedy this, some lenses show T-stops instead of, or in addition to, f-stops. **T-stops** (short for transmission stops) are f-stops that have been adjusted to take into account the amount of light that is lost, dissipated, or absorbed by that particular lens. T-stops are simply more accurate f-stops. If a lens has T-stops, they will always be found on the aperture ring in red (f-stops are in white). Using T-stops is simple and more accurate. After you determine your exposure (shown as f-stops on your light meter), simply set the T-stop scale instead. High-quality prime lenses lose so little light that T-stops are not necessary. Zoom lenses, however, utilize many more lens elements and can lose as much as one-third to a full stop before the light finally reaches the focal plane.

DEPTH OF FIELD

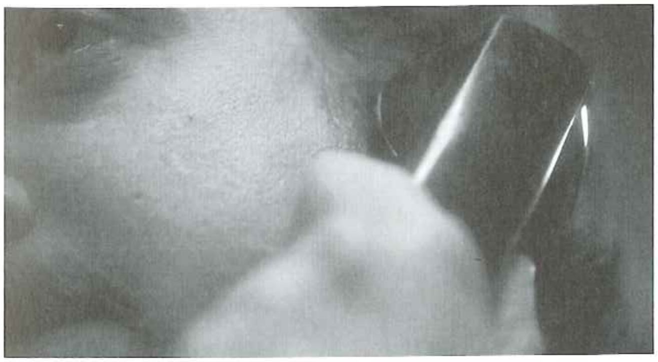
As we discussed earlier, the point at which the lens focus is actually set, and there can be only one setting, is called the plane of critical focus. However, when we look at an actual photographed image, we notice that there is always an area, both in front of and behind this plane of focus, that also appears to be in focus. This range of apparent focus along the z-axis is called the **depth of field** (DOF). The relative depth or shallowness of this area is not fixed. It can be as shallow as a few inches or as deep as infinity (!) depending on a number of variables. Because our eye cannot see the depth of field being registered on the film, it is important to have some way to predict how deep this range will be in order for us to truly know what our final image will look like. Also, what is especially important is that this range can, to a certain extent, be controlled. As with every other controllable variable associated with the lens, depth of field can and should be manipulated in order to serve the content and visual style of your movie (see Figure 3-11 in Chapter 3).

Creating a frame with a **shallow depth of field** makes your subject stand out from the environment and gain prominence in the frame, because objects both in front of and behind the subject are out of focus and indistinct. Adopting a **deep depth of field** increases the amount of information we see along the z-axis and therefore you gain environmental detail that can inflect the mood of the scene and the narrative content. Learning to control depth of field and use it creatively is a big step toward harnessing the aesthetic power of a lens for your needs (Figure 10-18). There is a practical dimension to DOF as well. If, for example, you have a lot of character movement away from and toward the camera, you might think about using a deep depth of field to keep your subject in focus without having to resort to complex focus pulling.

Controlling Depth of Field

The primary factor in determining depth of field is the size of the image format. The smaller the format, the deeper the depth of field tends to be. It is easier to get a deep DOF in 16mm film than it is in 35mm film. And consumer video cameras, with very small CCD chips, tend to have very deep depths of field. However, as one of the controllable variables, production format is not especially flexible because it is usually chosen for reasons more pressing than its depth of field potential. There are three other variables that determine the actual range of DOF over which we have some control:

- *The aperture opening.* The larger the aperture opening (smaller f-stop numbers), the shallower the DOF will be, and the smaller the aperture opening (larger f-stop numbers), the deeper the DOF will be. That is why scenes shot in very low light situations have such a shallow depth of field that we sometimes can see an eye in focus, but the ear, just a few inches back, is out of focus. Conversely, scenes shot in brightly lit environments can have a DOF so deep that it appears that everything in the background, as far as we can see, is in focus.



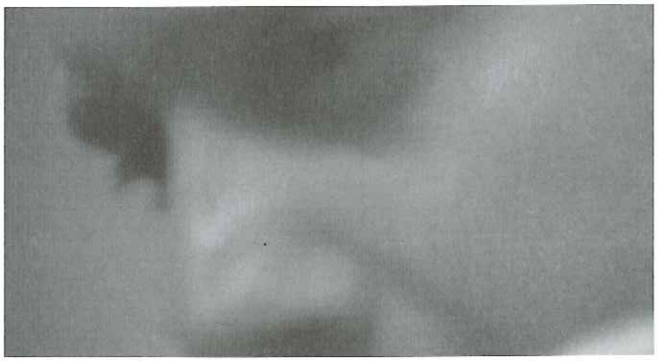


Figure 10-18 The very shallow depth of field in this scene from Payne's *Sideways* (2004) causes Miles (Paul Giamatti) to fall in and out of focus, reflecting his inebriated state when he places an ill-advised call to his ex-wife.

- *The focal length of the lens.* The longer the focal length of the lens, the shallower the DOF will be, and the shorter our lens, the deeper our depth of field will be. Wide-angle lenses create deeper depth of field than telephoto lenses.
- *The focus point setting (distance of the critical plane of focus).* The closer to the camera the focus setting, the shallower the depth of field will be, and the farther away we place the plane of critical focus, the deeper the DOF will be.

To predict what the DOF for any shot will be, filmmakers consult standard DOF tables like those found in the *American Cinematographer Manual* or online (see the box below). These tables are very simple to read and will tell you exactly what in your frame will appear to be in focus—so there will be no surprises when you get the film back from the lab. It is then up to you to use this information to creative advantage. Figure 10-19 shows two DOF tables. You will notice that the four variables we discussed for controlling the depth of field are part of the calculation. First, these are for the 16mm film format (other formats, like 35mm film require different tables). Each table is for a specific focal length lens (located at

Lens Focal Length: **25mm** — **DOF table: 16mm Film Format** — CoC = .015mm (.0005")

focus distance (feet)	f/1.4		f/2		f/2.8		f/4		f/5.6		f/8		f/11		f/16	
	Near	Far	Near	Far	Near	Far	Near	Far	Near	Far	Near	Far	Near	Far	Near	Far
2	1' 11.5"	2' 0.5"	1' 11.3"	2' 0.7"	1' 11.1"	2' 1"	1' 10.7"	2' 1.4"	1' 10.2"	2' 2.1"	1' 9.6"	2' 3"	1' 8.7"	2' 4.5"	1' 7.6"	2' 6.9"
4	3' 10.1"	4' 2"	3' 9.4"	4' 2.9"	3' 8.4"	4' 4.2"	3' 7.1"	4' 6.2"	3' 5.3"	4' 9.3"	3' 3"	5' 2.3"	3' 0.2"	5' 11"	2' 8.9"	7' 4.7"
6	5' 7.8"	6' 4.7"	5' 6.3"	6' 6.8"	5' 4.1"	6' 10"	5' 1.4"	7' 3.1"	4' 9.8"	7' 11.4"	4' 5.5"	9' 2.1"	4' 0.3"	11' 9"	3' 6.5"	19' 6"
8	7' 4.7"	8' 8.6"	7' 2"	9' 0.6"	6' 10.5"	9' 6.8"	6' 5.9"	10' 5"	6' 0.3"	11' 11"	5' 5.6"	14'11"	4' 10"	23' 3"	4' 1.8"	109'
10	9' 0.8"	11' 2"	8' 8.8"	11' 8"	8' 3.6"	12' 7"	7' 9"	14' 1"	7' 11"	17'	6' 3.9"	23' 10"	5' 5.9"	56'	4' 7.5"	∞
12	10' 8"	13' 8"	10' 3"	14' 6"	9' 7.5"	15' 11"	8' 10.8"	18' 5"	8' 0.4"	23' 8"	7' 0.8"	39' 8"	6' 0.5"	880'	5' 0.1"	∞
14	12' 3"	16' 4"	11' 8"	17' 7"	10' 10"	19' 8"	9' 11.4"	23' 7"	8' 10.6"	33'	7' 8.6"	75'	6' 6.1"	∞	5' 3.9"	∞
16	13' 9"	19' 2"	13'	20' 10"	12'	23' 10"	10' 11"	29' 11"	9' 7.8"	46' 11"	8' 3.4"	234'	6' 10.9"	∞	5' 7.1"	∞
18	15' 2"	22' 1"	14' 3"	24' 5"	13' 2"	28' 7"	11' 10"	37' 10"	10' 4"	70'	8' 9.4"	∞	7' 3"	∞	5' 9.7"	∞
20	16' 7"	25' 2"	15' 6"	28' 3"	14' 2"	34'	12' 8"	47' 11"	11'	114'	9' 2.8"	∞	7' 6.6"	∞	6'	∞
30	22' 11"	43' 5"	20' 10"	53'	18' 6"	79'	16'	241'	13' 5"	∞	10' 11"	∞	8' 7.6"	∞	6' 8"	∞
40	28' 4"	68'	25' 3"	96'	21' 11"	230'	18' 5"	∞	15' 1"	∞	12'	∞	9' 3.5"	∞	7' 0.6"	∞
50	33'	103'	28' 11"	185'	24' 7"	∞	20' 4"	∞	16' 4"	∞	12' 9"	∞	9' 8.9"	∞	7' 3.7"	∞
∞	97'	∞	68'	∞	48' 5"	∞	34' 3"	∞	24' 3"	∞	17' 2"	∞	12' 2"	∞	8' 7.5"	∞

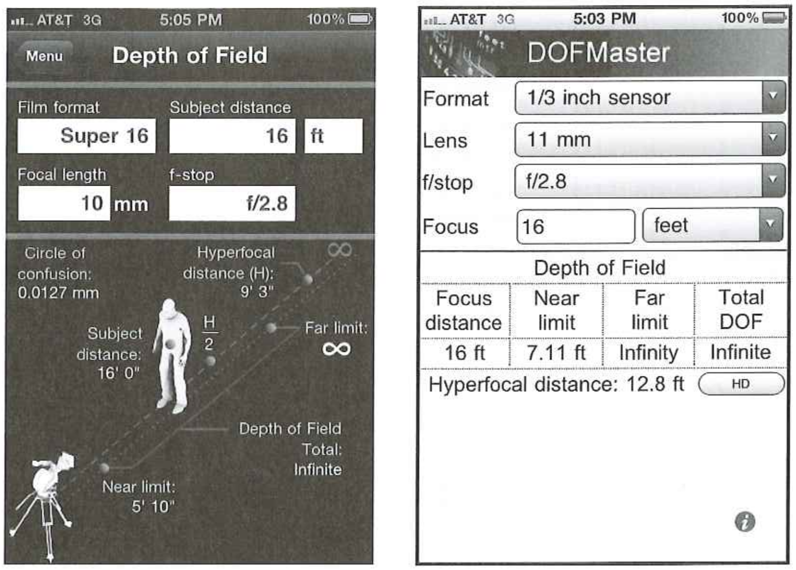
Lens Focal Length: **100mm** — **DOF table: 16mm Film Format** — CoC = .015mm (.0005")

focus distance (feet)	f/1.4		f/2		f/2.8		f/4		f/5.6		f/8		f/11		f/16	
	Near	Far	Near	Far	Near	Far	Near	Far	Near	Far	Near	Far	Near	Far	Near	Far
7	6' 11.6"	7' 0.4"	6' 11.5"	7' 0.5"	6' 11.3"	7' 0.7"	6' 11"	7' 1"	6' 10.6"	7' 1.5"	6' 10"	7' 2.1"	6' 9.2"	7' 3"	6' 8.1"	7' 4.3"
8	7' 11.5"	8' 0.5"	7' 11.3"	8' 0.7"	7' 11.1"	8' 1"	7' 10.7"	8' 1.4"	7' 10.1"	8' 1.9"	7' 9.4"	8' 2.8"	7' 8.3"	8' 4"	7' 6.9"	8' 5.7"
10	9' 11.3"	10' 1"	9' 10.9"	10' 1"	9' 10.5"	10' 2"	9' 9.9"	10' 2"	9' 9.1"	10' 3"	9' 7.9"	10' 4"	9' 6.3"	10' 6"	9' 4.1"	10' 9"
12	11' 11"	12' 1"	11' 11"	12' 2"	11' 10"	12' 2"	11' 9"	12' 3"	11' 8"	12' 5"	11' 6"	12' 6"	11' 4"	12' 9"	11' 1"	13' 1"
14	13' 11"	14' 2"	13' 10"	14' 2"	13' 9"	14' 3"	13' 8"	14' 4"	13' 6"	14' 6"	13' 4"	14' 9"	13' 1"	15' 1"	12' 9"	15' 7"
16	15' 10"	16' 2"	15' 9"	16' 3"	15' 8"	16' 4"	15' 7"	16' 6"	15' 5"	16' 8"	15' 2"	17'	14' 10"	17' 5"	14' 4"	18' 1"
18	17' 10"	18' 3"	17' 9"	18' 4"	17' 7"	18' 5"	17' 5"	18' 7"	17' 3"	18' 10"	16' 11"	19' 3"	16' 6"	19' 10"	15' 11"	20' 8"
20	19' 9"	20' 3"	19' 8"	20' 4"	19' 6"	20' 6"	19' 4"	20' 9"	19'	21' 1"	18' 8"	21' 7"	18' 2"	22' 3"	17' 6"	23' 4"
30	29' 5"	30' 7"	29' 3"	30' 10"	28' 11"	31' 2"	28' 6"	31' 9"	27' 10"	32' 6"	27' 1"	33' 8"	26'	35' 5"	24' 8"	38' 4"
40	39'	41' 1"	38' 7"	41' 6"	38' 1"	42' 2"	37' 4"	43' 2"	36' 3"	44' 7"	34' 11"	46' 10"	33' 2"	50'	31'	56'
50	48' 5"	52'	47' 10"	52'	47'	53'	45' 10"	55'	44' 4"	57'	42' 4"	61'	39' 9"	67'	36' 8"	79'
75	72'	79'	70'	80'	68'	83'	66'	87'	63'	93'	59'	103'	54'	122'	48' 6"	165'
100	94'	107'	92'	110'	89'	115'	85'	122'	80'	135'	73'	157'	66'	206'	58'	369'
∞	1547'	∞	1094'	∞	774'	∞	547'	∞	387'	∞	274'	∞	194'	∞	137'	∞

Figure 10-19 DOF tables for 25mm and 100mm lenses (16mm film format). Depth of field tables are essential on location for determining which areas of the frame are in or out of focus. (Downloadable DOF tables for 16mm format can be found at www.voiceandvisionbook.com or DOF Masters.com.)

the top, left of the chart). The two here are for the 25mm and 100mm lenses. The lens focus distance is located on the left vertical column, and the f-stop settings are on the top, horizontal column. Let's see how to read these very simple tables.

Look at the DOF table for the 25mm lens (normal lens). If we are focused at 16 feet with an aperture of f/2.8, we can see that the DOF range is 12′ to 23′ 10″. All objects between these points will appear to be in focus even though your actual plane of critical focus is 16 feet. The range of apparent focus along the z-axis is therefore 11′ 10″. Now read across and along the f-stop scale for the same focus point (16 feet) and you will see the DOF get deeper as the aperture gets smaller, and as the aperture opens up, the DOF gets shallower. Now, read down the various lens focus distances for f/2.8 and you will notice that the DOF gets shallower the closer the focus point is, and deeper the farther the focus is set.



■ **Figure 10-20** Many DOF calculators are available online and as apps for smartphones. Some are free, like this Kodak iPhone app *(left)*,others charge a nominal fee, like the highly versatile DOF Master app *(right)*, which calculates DOF for all film and video formats.

Now look at the table for the 100mm lens (telephoto) and compare the same settings (focus at 16 feet and aperture at f/2.8). The DOF is 15′ 8″ to 16′ 4″. The range is only 8 inches—much shallower. Now, go to Figure 10-20 and look at the DOF calculation on the Kodak smartphone app *(left);* you'll see the same settings (focus at 16 feet and aperture at f/2.8), but this time calculated for a 10mm lens. Now, with the wide angles lens, the DOF range is from 5′ 10″ to infinity!

Getting back to our examples for setting focus for narrative and emotional impact (Figures 10-10 and 10-11 on page 228-229), you now understand that it's not just a matter of where you set your focus ring, but you must also understand just how deep the focus range is in order to accurately achieve the shot you want. Using a wide-angle lens and lots of light (small aperture) might have brought Anton Chigurh into the DOF range and the character would have lost much of his menace and mystery. A DOF only a few feet deeper would have brought Oskar and other children into sharp focus; we would likely not have even noticed the bullies, and the shot would have lost its tension and meaning.

in practice

■ DEPTH OF FIELD CALCULATION TOOLS

To predict what the DOF for any shot will be, filmmakers consult standard DOF tables like those found in the *American Cinematographer Manual.* You'll also find a set of DOF tables for the 16mm format at www.voiceandvisionbook.com. Additionally, you can easily generate and print out DOF tables for any film or video format at www.dofmaster.com. The DOFMaster website also offers a DOF calculator where you enter in the four DOF variables mentioned earlier and it will instantly calculate your precise DOF range. Panavision has the same DOF calculator tool at www.panavision.com/tools.php. Additionally, there are a number of smartphone apps that allow you to calculate DOF in the field, including the free *Kodak Cinema Tools* app, which only calculates DOF for film formats. There are a number of DOF apps you can download for a nominal price that work for all film and digital video formats. Two of these are the *DOFMaster* app and David Eubank's *PCam Film+Digital Calculator* (**Figure 10-20**).

The 1/3–2/3 Rule

You may have noticed while you were reading the DOF tables that there seems to be more of the range of apparent focus behind the actual focus setting than in front of it. This is always the case. The **1/3–2/3 rule** for DOF tells us that two-thirds of the depth range along the z-axis is behind the focus point and one-third is in front (Figure 10-21). This is an important principle to consider when you are trying to move objects into and out of the range of apparent focus (see the In Practice box, "Working with DOF").

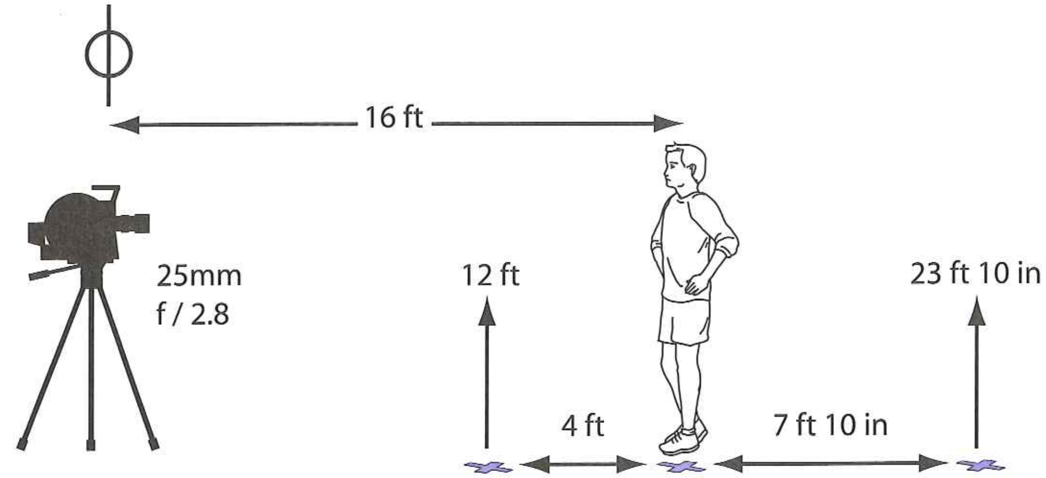


Figure 10-21 The 1/3–2/3 rule. One-third of the DOF range lies in front of the plane of critical focus and two-thirds behind it.

in practice

WORKING WITH DOF

In a final project for an intermediate film production class, Gisela M. ended her film with a shot for which depth of field was a critical element of telling her revenge fantasy story:

> *Joey is a materialistic cad who leaves his sweet girlfriend for a woman who makes very good money. But Joey is quickly dumped when the woman finds out that he has no money himself. In the last scene we see a rejected Joey riding a train, on his way back to reconnect with his girlfriend—but he's out of luck.*

Figure 10-22 Gisela's storyboard shows what must be seen clearly in the frame: Joey's face looking out the train window and the newspaper headline directly behind him.

Here is our essential train shot. The train is moderately full; we see Joey in a medium close-up shot, sitting alone and gazing out the window. Passengers in front of him (foreground) and behind him (background) are engrossed in their newspapers. The guy sitting right behind Joey turns the page and we see a photograph of Joey's smiling girlfriend under the headline "Bronx Woman Wins 10 Mil. Jackpot" right behind Joey's head. Figure 10-22 is a storyboard of the frame Gisela was after and an overhead diagram of the setup for this train shot.

Obviously, it is essential for the audience to read the headline. The fact that Joey's girlfriend has struck it rich and that Joey will likely never get her back provides the central irony of the film. Also, this shot allows our audience to know more than the character. We see that his scheming has backfired on him and we can predict the final encounter with the girlfriend, so it's not necessary to show it. This one shot contains both narrative information and the humorous tone of a well-timed punch line.

in practice

Here is Gisela's technical information: she was shooting on 16mm film and to get a nice medium close-up on Joey, along with a dynamic composition, including foreground, midground, and background, she used an 85mm lens with the camera set up 15 feet away from Joey. The newspaper headline was 3 feet behind Joey's head, 18 feet from the film plane. Given the intensity of the light in the train car, Gisela set the f/stop at f.11.

Everything seems fine and a careless filmmaker would simply focus on the face of our subject Joey (set focus to 15 feet) and just take the shot as is. However, when the footage returns from the lab, they would discover, too late, that the news photo and headline are out of focus and cannot be read. By simply consulting a DOF chart, the filmmaker would have seen that, given the variables (85mm lens, f.11, focus at 15 feet), the DOF range was 13′ 7″ to 16′ 9″, not deep enough to include the newspaper.

However, Gisela was a careful filmmaker and she checked the DOF chart and knew she needed to make an adjustment. But which one? Which variable should she choose to obtain the depth of field necessary to see Joey and read the newspaper, to deliver the ironic punch line to resolve the story! Let's look at her options (**Figure 10-23**):

- *Changing the lens.*
  If Gisela were to change the lens focal length to 65mm, with all other things remaining the same, her DOF would deepen to a range of 12′ 8″ to 18′ 4″. That's great; the newspaper is now in focus—but wait: all things have not remained the same. Changing a lens affects many other aspects of her frame besides DOF. First, with the shorter focal length lens we might not be able to read the newspaper anymore, even if it is in focus, because it appears too far away. Second, Joey is now smaller in the frame and the extras in the foreground take on greater, and maybe excessive, prominence. Also, Gisela's field of view is wider, maybe wide enough to see things she wanted to keep outside the frame, like a light stand or a microphone. Obviously, changing the focal length will require other adjustments: move some lights, shift the extras around, and maybe it's even necessary to move the camera closer to Joey and the newspaper. But wait! We know that a closer camera-to-subject distance will *decrease* DOF and Gisela will lose much of the depth of field she just gained. There's got to be an easier way.
- *Adjusting the aperture variable.*
  If it's possible to add more light, then Gisela can leave her focal length and camera-to-subject distance as it is and simply close the aperture down. Doubling the intensity of the light means she can shoot at f/16. Consulting the charts shows that at that f-stop her DOF is 13′ to 17′ 5″. Not quite deep enough. According to the charts, she needs to get to f/22 (even smaller) before the depth of field deepens to 12′ 5″ to 19′. Shooting at f/22 would mean that everything she needs will be in focus and she gets to keep the framing she had in mind. However, adding *four times* the light isn't always that easy; in fact, on a very low-budget shoot, like Gisela's, there was no way to quadruple the amount of light. So what else?
- *Adjusting the plane of focus.*
  So Gisela couldn't add any light at all and she didn't want to change lenses: what now? Should she rethink the shot completely? Not necessarily. Remember that one-third of the DOF is in front of the plane of focus and two-thirds is behind! Also remember that adjusting the plane of critical focus farther from the film plane actually *deepens* the DOF. Obviously, there is no reason to have the plane of critical focus exactly on our subject Joey as long as he falls within the DOF range. So Gisela simply adjusted her focus ring to 16 feet and her DOF shifted back toward the newspaper and deepened slightly to 14′ 3″ to 18′ 1″. The newspaper is now readable and Joey falls within the near end of the DOF range.

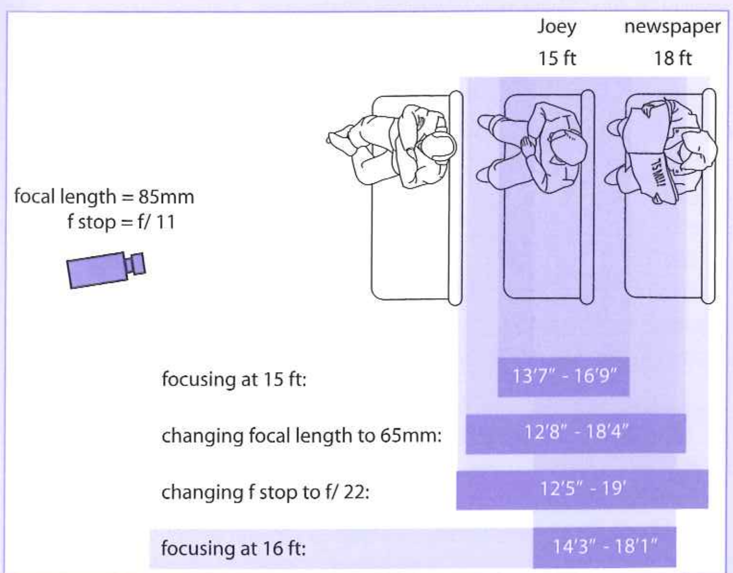


Figure 10-23 After some research, Gisela found the right combination of aperture, camera-to subject-distance, and focal length to create the shot exactly the way her story needed it. (see this as an interactive figure online.)

Circle of Confusion

As we have discussed, depth of field is a phenomenon of *apparent* focus along the z-axis range, but let's look a little closer. Focus, as we have defined it, is achieved when a point of light coming off our subject is registered as a point of light on the focal plane and we know that there is only one setting that will be truly in focus (i.e., setting the focus ring to 16 feet). This means that the light points emanating from the area in front of and behind the plane of critical focus are not registered as a points; rather, they begin to spread larger and larger and get fuzzier the farther away their origin is from the focus setting point. However, neither the human eye, nor film stocks, nor CCD chips can distinguish between very small degrees of unsharpness. There is an acceptable size range to which a point of light can spread (be technically out of focus) and still *appear* to be in focus. For 16mm film, a point of light can spread to a diameter of .015mm or 0.0005″ (that's five ten-thousandths of an inch) on the film, and our eye will see it as in focus. Beyond that, the image starts to appear fuzzy. This measurement of acceptable diameter, which creates the appearance of focus, is called the **circle of confusion (the CoC).** You can find the CoC for the shooting format on any DOF table (see Figure 10-19). Every format size has its own acceptable CoC measurement. For 35mm film format, the CoC is 0.001″. In video, the CoC for a ¼″ CCD is 0.008mm, for a ⅓″ CCD it is 0.011 and for a ½″ CCD it is 0.016mm.

LENS CONSIDERATIONS ON DV

Although all of the principles of optics apply equally to film and DV lenses, there are a few special details concerning lenses that must be considered when shooting on DV.

DOF and DV

Using DOF tables or a DOF calculator is standard practice in film production because film camera viewfinders are not clear enough to really *see* your range of apparent focus. Because film is projected many times larger than the original frame, absolute accuracy is essential. However, DOF tables are rarely used in video production for two reasons. First, when DOF is absolutely critical to a video project, there is usually a production field monitor on the set for reference (see page 264). This monitor is many times larger than the viewfinder and allows one to see DOF fairly clearly. Also, it was always assumed that video was a small-screen TV medium, so who could tell DOF to the inch anyway? That, of course, is changing as home TVs are growing bigger every month, and more and more films originating on DV (SD and HD) find their way into theaters and are projected as big as any 35mm film.

Most consumer and midlevel digital video cameras have very small CCD chips; ¼″, ⅓″, and ⅔" chips are most common. Small imaging devices, as we have discussed, produce deeper depth of field. One of the main complaints of D.P.s using video is that the DOF is too deep. There are a number of remedies for this if you want to achieve a shallow depth of field. Most of these strategies involve staying at the widest aperture possible by either keeping the lighting intensity low or, if you cannot control the illumination of the scene (e.g., a sunny exterior shoot), utilizing the camera's built-in **neutral density** filters to block light or using the **electronic shutter control** to reduce the light entering the camera. Either way, reducing the light will force your aperture to open up and your DOF will narrow.

> *One of the characteristics of digital cameras that I particularly like is that they have such deep focus. With most film cameras the depth of field is limited, and so focus becomes crucial in respect of the actor's movement, since it's so important that the character is always in focus. Most digital cameras, though—certainly when they're on their wide angle mode—have such depth of field that you don't really have to worry about focus.*
>
> **Mike Figgis (From *Digital Filmmaking*, Faber and Faber, 2005)**

If you are shooting on DV and wish for your project to have shallow DOF throughout, then you might consider using a **35mm lens adapter kit** for DV cameras. Most 35mm lens adapters consist of a lens mount that utilizes standard 35mm lenses that focus the light from the scene onto a vibrating ground glass screen positioned in front of the existing video camera lens (Figure 10-24). The video camera essentially shoots the image, which has the dimensions of a 35mm film frame, off the ground glass screen. Given the size of the imaging frame and the length of the lenses (interchangeable), you effectively achieve, on video, the same perspective and DOF possibilities as the 35mm film format. The downside to lens adapters is that they make a mobile video camera much more cumbersome and conspicuous.

■ **Figure 10-24** Lens adaptors, like the Letus Elite *(top)*, allow DV camcorders to take advantage of a large range of high-quality 35mm lenses. Filmlike shallow DOF, as in this shot from *Kiarra's Escape (bottom)*, is easily achievable on video with the use of a lens adaptor. (video examples of a scene shot with and without a lens adaptor are at the companion website.)

Focusing a Zoom Lens

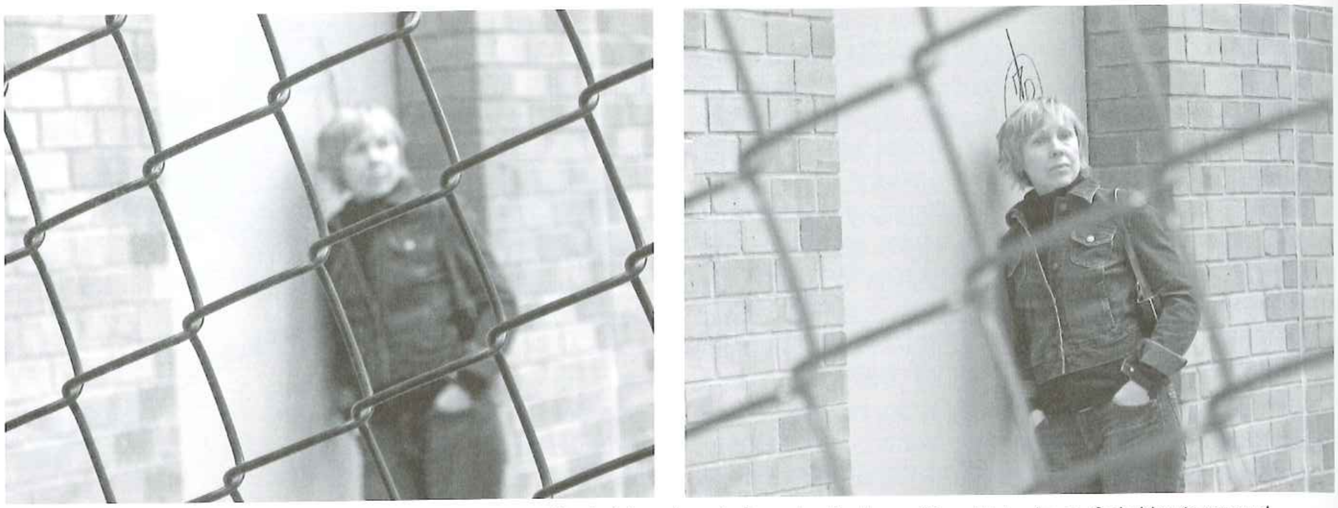
Because depth of field becomes narrower as we move toward the telephoto end of a zoom lens, it is possible to have an image perfectly in focus with a wide-angle setting, and simply changing the focal length will throw the subject out of focus. The proper way to assure that focus will be maintained throughout the zoom range of a lens is to find your focus at the extreme telephoto end of the range, then pull out to the focal length you want. Going from telephoto to more wide angle will only increase your DOF and the subject will remain in focus. This is especially important to know if you are shooting on the fly—as in many documentary situations. The procedure for focusing a zoom is this: First zoom all the way into the subject you want to have in focus (for example, the eyes of your talent). Adjust your focus until the image is sharp. Now zoom out and find your initial frame. The subject will now remain in focus for the entire zoom range. This is called **presetting focus.**

Video Lenses and Automatic Functions

Unlike film cameras, which oblige us to choose focus and aperture settings manually, most DV cameras provide an automatic setting option for both of these functions. As I mention throughout this book, it is preferable to turn off all automatic functions in your camcorder. Manual settings ensure that the filmmaker is in control of all variables and therefore in control of how their film looks. Remember, choosing your focus is a creative and aesthetic decision: Why would we want to hand that important decision to a machine, with no aesthetic judgment at all? By using automatic focus and exposure, your film cannot help but look like every other film using auto functions.

All professional video cameras employ lenses with focus, f-stop, and zoom rings etched with their respective scales. However, many consumer and industrial DV cameras place some or all of that information within menus. It is important for you to familiarize yourself with these functions and figure out how to access all manual modes for your particular camera before you are on the set and shooting your project (Figure 10-25).

■ **Figure 10-25** Most video cameras have a way of switching from automatic to manual focusing, an important feature for maintaining complete control over the way your images are recorded.



■ **Figure 10-26** Video cameras set to auto focus have trouble deciding where to focus in situations with multiple planes. Switching to manual focusing solves this problem, letting the users set the focus according to their needs.

One significant problem with the **auto focus** function is that it favors objects in the center of the frame—which might not be appropriate for the composition you want—and it tends to shift focus in the middle of a shot when anything moves across the foreground of the frame. Let's say we have a composition in which your subject is tucked over to the right of the frame, with a forest behind her. It's likely that the camera will choose to set focus automatically for that which is in the middle, the forest, leaving the subject fuzzy. Auto focus is also easily confused by images with multiple planes. For example, let's say we wish to shoot a character who is 10 feet behind a chain-link fence. The auto focus will likely select for the fence in the foreground, especially if your subject is slightly off center. Quite often, auto focus mechanisms will go crazy in a situation like this, shifting arbitrarily from the fence to the character and back to the fence, searching for focus but never quite settling on it (Figure 10-26).

A common procedure for setting video focus is to zoom in to what you want to be in focus. Allow the auto focus to choose its setting and then flip into **manual mode.** Now when you pull back and readjust your frame, with the subject to one side, the camera will hold your focus point. Also, if a car should pass through in the foreground, your camera will not try to change the focus setting.