SECTION

4.1

What Lenses Are

The lens determines what the camera can see. One type of lens can provide a wide vista even though you may be relatively close to the scene; another type may provide a close view of an object that is quite far away. Different types of lenses also determine the basic visual perspective—whether you see an object as distorted or whether you perceive more or less distance between objects than there really is. They also contribute to a large extent to the quality of the picture and how much you can zoom in or out on an object without moving the camera. This section examines what lenses can do and how to use them.

- **TYPES OF ZOOM LENSES**
  Studio and field lenses, zoom range, and lens format
- **OPTICAL CHARACTERISTICS OF LENSES**
  Focal length, focus, light transmission (iris, aperture, and f-stop), and depth of field
- **OPERATIONAL CONTROLS**
  Zoom control, digital zoom lens, and focus control

TYPES OF ZOOM LENSES

When listening to production people talk about *zoom lenses*, you will most likely hear one person refer to a studio rather than a field zoom, another to a 20× lens, and yet another to a zoom lens that fits a ⅔-inch image format. And all may be talking about the same zoom lens. This section looks at these classifications.

STUDIO AND FIELD LENSES

As the name indicates, *studio zoom lenses* are normally used with studio cameras. *Field zooms* include large lenses mounted on high-quality cameras that are used for remote telecasts, such as sporting events, parades, and the like. They also include the zoom lenses attached to ENG/EFP cameras. The lenses of consumer camcorders usually come with the camera and cannot be exchanged. Some high-end prosumer models, however, allow you to attach a variety of zoom lenses. Because you can, of course, use a field lens in the studio and vice versa, a better and more accurate way to classify the various zoom lenses is by their zoom range and lens format, that is, what cameras they fit.

ZOOM RANGE

If a zoom lens provides an overview, for example, of the whole tennis court and part of the bleachers when zoomed all the way out and (without moving the camera closer to the court) a tight close-up of the player's tense expression when zoomed all the way in, the lens has a good zoom range. The *zoom range* is the degree to which you can change the focal length of the lens (and thereby the angle of view, or vista) during the zoom.

The zoom range of a lens is often stated as a ratio, such as 10:1 or 40:1. A 10:1 zoom means that you can increase the shortest focal length ten times; a 40:1, forty times. To make things easier, these ratios are usually listed as 10× (ten times) or 40× (forty times), referring to the maximum magnification of the image of which the lens is capable. SEE 4.1

The large (studio) cameras that are positioned on top of the bleachers for sports coverage may have zoom ranges of 40× and even 70×. In the studio the cameras are well served by a 20× zoom lens. The smaller and lighter ENG/EFP camera lenses rarely exceed a 15× zoom range.

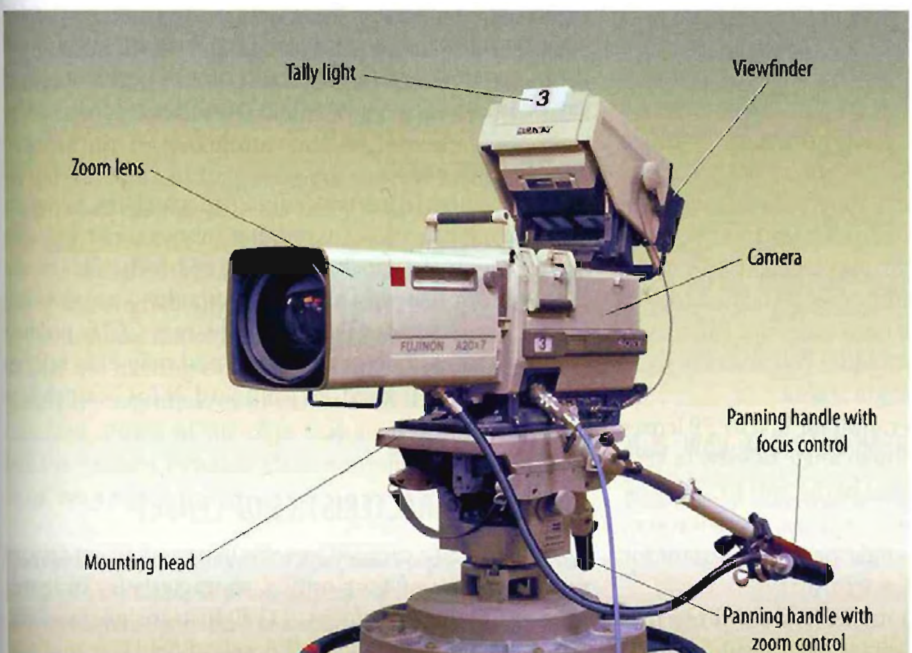
Optical and digital zoom ranges You may have noticed that the zoom range on a consumer camcorder is rather limited; an optical zoom range of 15× is considered excellent even for high-end consumer cameras. This is why consumer cameras offer the option of increasing the zoom range digitally. During an optical zoom to a tighter shot, the image magnification is achieved by moving elements within the lens. In effect, you are continually changing the focal length during the zoom-in or zoom-out. In *digital zooming* such a change in focal length does not take place.

4.1 MAXIMUM ZOOM POSITIONS OF A 10× LENS
The 10x zoom lens can increase its focal length ten times. It magnifies a portion of the scene and seems to bring it closer to the camera and ultimately the viewer.

For a zoom-in, the electronics of the camera simply select the center portion of the long shot and enlarge the cropped area to full-screen size. The problem with digital zooming is that the enlarged pixels noticeably reduce the resolution of the image (recall the mosaic tiles in chapter 3). At one point in digital zooming, the pixels can get so large that they look more like a special effect than a magnification of the original image. Higher-end camcorders, which have a digital zoom option, try to restore the full-pixel resolution of the original image by a process called *interpolation*. But despite this digital wizardry, the digital zoom does not achieve the crispness of the optical zoom.

Studio, field, and ENG/EFP lenses are all detachable from the camera. Most consumer camcorders have a built-in lens that cannot be detached. SEE 4.2 AND 4.3

Studio and large field lenses Note that a 20× studio lens becomes a field lens if it is used "in the field," that is, for a production that happens outside the studio. Generally, however, field lenses have a much greater zoom



4.2 STUDIO ZOOM LENS
High-quality studio lenses are quite heavy and often larger than the camera itself. They cannot be mounted on an ENG/EFP camera.

4.3 ENG/EFP ZOOM LENS
The ENG/EFP camera lens is considerably lighter and smaller than the studio zooms. Although these lenses are not as high quality as studio lenses, ENG/EFP lenses nevertheless have many of the studio zoom's features, such as servo and manual zoom controls, automatic iris control, and sometimes an autofocus feature.

range (from 40× to 70×) than studio cameras. Some field lenses have even a greater zoom range, allowing the camera operator to zoom from a wide establishing shot of the football stadium to a tight close-up of the quarterback's face. Despite the great zoom range, these lenses deliver high-quality pictures even in relatively low light levels. For studio use such a zoom range would be unnecessary and often counterproductive.

ENG EFP **ENG/EFP lenses** These lenses are much smaller, to fit the portable cameras. Their normal zoom range varies between 11× and 20×. A 15× zoom lens would be sufficient for most ENG/EFP assignments, but sometimes you might want a closer view of an event that is relatively far away. You would then need to exchange the 15× zoom lens for one with a higher zoom range—such as 20× or even 30×. You can also use a *range extender* (discussed later in this chapter), which would let you zoom beyond the normal zoom range into a tighter shot.

A more important consideration for ENG/EFP lenses is whether they have a wide enough angle of view (a very short focal length), which would allow you to shoot in highly cramped quarters, such as in a car, a small room, or an airplane. Also, the wide-angle view is important for shooting in the wide-screen 16 × 9 format.

Many lenses have digital or mechanical stabilizers that absorb at least some of the picture wiggles resulting from operating the camera, especially when in a narrow-angle (zoomed-in) position. Realize, however, that such stabilizers cause an additional drain on the battery. Use this feature only if you don't have a tripod or are unable to stabilize the camera in any other way. ◀

Consumer camcorder lenses These zoom lenses generally have an optical zoom range of 10× to 18×. You may have noticed that the problem with zoom lenses on consumer camcorders is that the maximum wide-angle position is often not wide enough, despite their good zoom range. Most camcorders have some sort of image stabilization. Some high-end prosumer models, which have a built-in lens, let you attach elements that allow a wider angle or tighter close-ups.

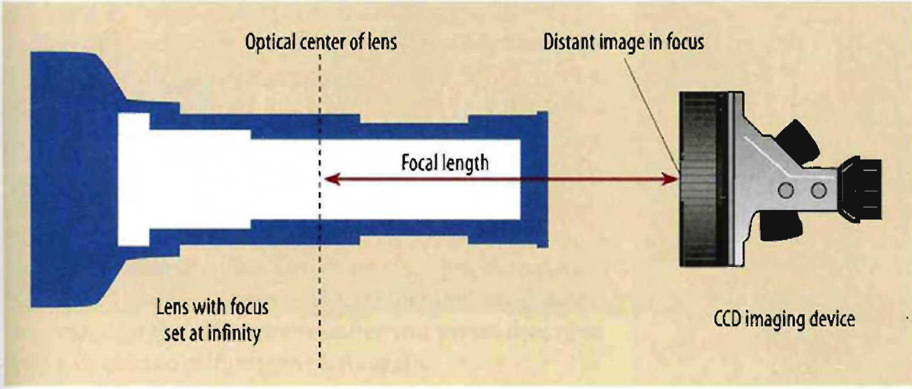
Range extenders If a zoom lens does not get you close enough to a scene from where the camera is located, you can use an additional lens element called a *range extender*, or simply an *extender*. This optical element, usually available only for lenses on professional cameras, does not actually extend the range of the zoom but rather shifts the magnification—the telephoto power—of the lens toward the narrow-angle end of the zoom range. Most lenses have 2× extenders, which means that they double the zoom range in the narrow-angle position, but they also reduce the wide-angle lens position by two times. With such an extender, you can zoom in to a closer shot, but you cannot zoom back out as wide as you could without the extender. There is another disadvantage to range extenders: they cut down considerably the light entering the camera, which can be problematic in low-light conditions.

LENS FORMAT

Because camera lenses are designed to match the size of the CCD imaging device, you may hear about a *lens format* or *image format* of ⅓-inch, ½-inch, or ⅔-inch. This means that you can use only a lens that fits the corresponding CCD image format. Like film, the larger CCDs produce better pictures. The term *lens format* may also refer to whether a lens is used for standard NTSC cameras or HDTV cameras.

OPTICAL CHARACTERISTICS OF LENSES

Effective use of a camera depends to a great extent on your understanding of four optical characteristics of lenses: (1) focal length; (2) focus; (3) light transmission—iris, aperture, and *f*-stop; and (4) depth of field.



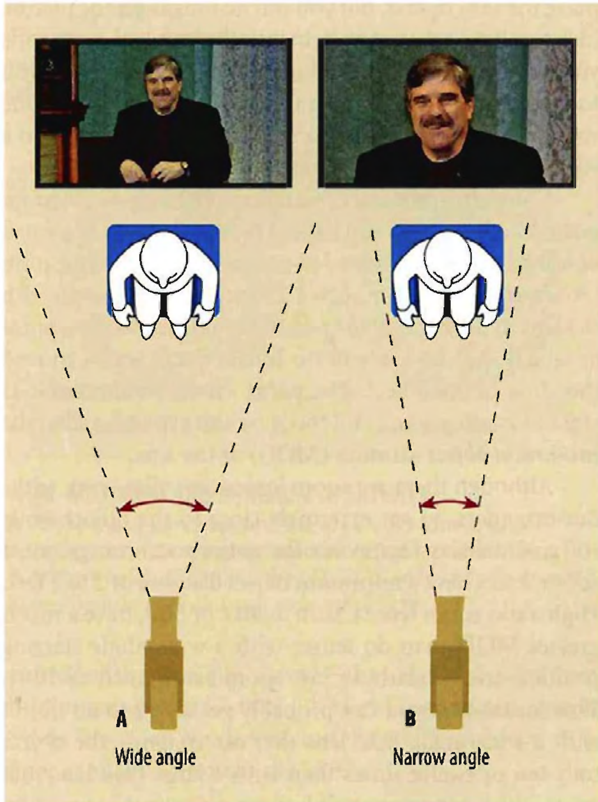
4.4 FOCAL LENGTH
The focal length is the distance from the optical center of the lens to the front surface of the imaging device.

FOCAL LENGTH

Technically, *focal length* refers to the distance from the optical center of the lens to the point where the image the lens sees is in focus. This point is the camera's imaging device. **SEE 4.4** Operationally, the focal length determines how wide or narrow a vista a particular camera has and how much and in what ways objects appear magnified.

When you zoom all the way *out*, the focal length of the lens is short and at the maximum wide-angle position; the camera will provide a wide vista. When you zoom all the way *in*, the focal length is long and at the maximum narrow-angle (telephoto) position; the camera will provide a narrow vista or field of view—a close-up view of the scene. **SEE 4.5** When you stop the zoom approximately halfway in between these extreme positions, the lens has the normal focal length. This means that you will get a "normal" vista that approximates your actually looking at the scene. Because the zoom lens can assume all focal lengths from its maximum wide-angle position (zoomed all the way out) to its maximum narrow-angle position (zoomed all the way in), it is called a *variable-focal-length lens.* **ZVL1** CAMERA→ Zoom lens→ normal | wide | narrow | try it

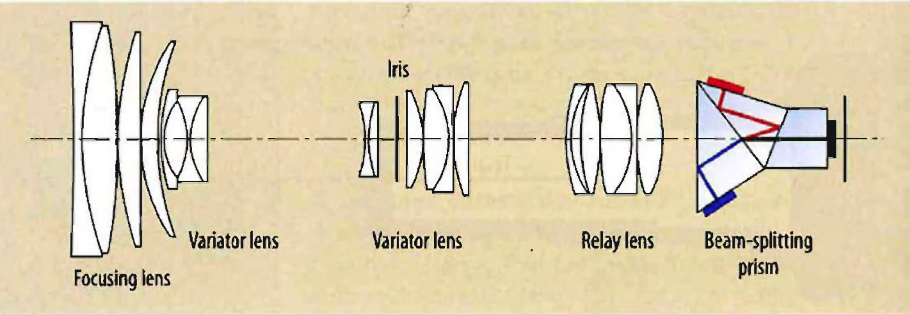
On the television screen, a zoom-in appears as though the object is gradually coming toward you. A zoom-out seems to make the object move away from you. Actually, all that the moving elements within the zoom lens do is gradually magnify (zoom-in) or reduce the magnification (zoom-out) of the object while keeping it in focus, but the camera remains stationary during both operations. **SEE 4.6**



4.5 WIDE-ANGLE AND NARROW-ANGLE ZOOM POSITIONS
A The wide-angle zoom position (zoomed out) has a wider vista (field of view) than **B**, the narrow-angle zoom position (zoomed in). Note that zooming in magnifies the subject.

Minimum object distance and macro position You will find that there is often a limit to how close you can move a camera (and lens) to the object to be photographed and still keep the picture in focus. This is especially

4.6 ELEMENTS OF A ZOOM LENS
A zoom lens consists of many sliding and stationary lens elements that interact to maintain focus throughout the continuous change of focal length. The front elements control the focus; the middle elements control the zoom.



problematic when trying to get a close-up of a very small object. Even when zoomed in all the way, the shot may still look too wide. Moving the camera closer to the object will make the shot tighter, but you can no longer get the picture in focus. Range extenders help little, but while they provide you with a tighter close-up of the object, they force you to back off with the camera to get the shot in focus. One way to solve this problem is to zoom all the way out to a wide-angle position.

Contrary to normal expectations, the wide-angle zoom position often allows you to get a tighter close-up of a small object than does the extended narrow-angle zoom position (zoomed all the way in with a 2× extender). But even with the lens in the wide-angle position, there is usually a point at which the camera will no longer focus when moved too close to the object. The point where the camera is as close as it can get and still focus on the object is called the *minimum object distance* (*MOD*) of the lens.

Although there are zoom lenses that allow you, without extenders, to get extremely close to the object while still maintaining focus over the entire zoom range, most zoom lenses have a minimum object distance of 2 to 3 feet. High-ratio zoom lenses, such as 40× or 50×, have a much greater MOD than do lenses with a wide-angle starting position and a relatively low zoom ratio (such as 10×). This means that you can probably get closer to an object with a wide-angle field lens that can magnify the object only ten or twelve times than with a large field lens that starts with a narrower angle but can magnify the scene fifty or more times.

Despite the relative advantage of wide-angle field lenses, many field lenses on ENG/EFP cameras have a *macro position*, which lets you move the camera even closer to an object without losing focus. When the lens is in the macro position, you can almost touch the object with the lens and still retain focus; you can no longer zoom, however. The macro position changes the zoom lens from a variable-focal-length lens to a fixed-focal-length, or *prime*, lens. The fixed focal length is not a big disadvantage because the macro position is used only in highly specific circumstances. For example, if you need to get a screen-filling close-up of a postage stamp, you would switch the camera to the macro position, but then you cannot use the camera for zooming until you switch back to the normal zoom mechanism.

FOCUS

A picture is "in focus" when the projected image is sharp and clear. The *focus* depends on the distance from the lens to the film (as in a still or movie camera) or from the lens to the camera's imaging device (beam splitter with CCDs). Simply adjusting the distance from the lens to the film or imaging device brings a picture into focus or takes it out of focus. In television zoom lenses, this adjustment is accomplished not by moving the lens or the prism block (beam splitter) but by moving certain lens elements relative to each other through the zoom focus control (see figure 4.6).

Focus controls come in various configurations. Portable cameras have a focus ring on the lens that you turn; studio cameras have a twist grip attached to the panning handle (see figure 4.18). Most consumer camcorders have an automatic focus feature, called *auto-focus*, which is discussed in the context of operational controls later in this section.

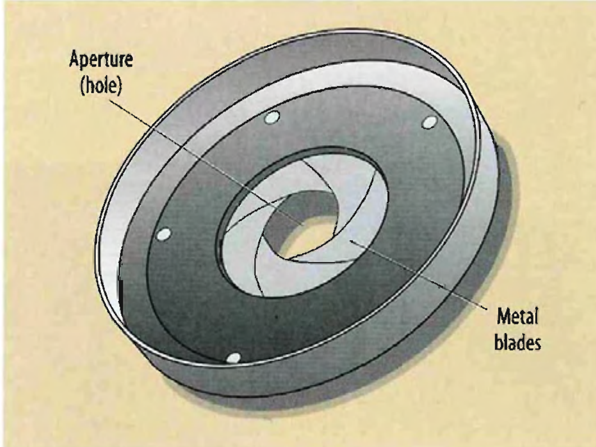
If properly preset, a zoom lens keeps in focus during the entire zoom range, assuming that neither the camera nor the object moves very much toward or away from the other. But because you walk and even run while carrying an ENG/EFP camera, you cannot always prefocus the zoom. In such cases you would do well by zooming all the way out to a wide-angle position, considerably reducing the need to focus. This is examined more thoroughly in the discussion on depth of field later in this section.

Presetting (calibrating) the zoom lens There is a standard procedure for *presetting*, or *calibrating*, the zoom lens so that the camera remains in focus throughout a zoom: Zoom all the way in on the target object, such as a newscaster on a news set. Focus on the newscaster's face (eyes or the bridge of her nose) by turning the focus control. When zooming back out to a long shot, you will notice that everything remains in focus. The same is true when you zoom in again. You should now be able to maintain focus over the entire zoom range. If you move the camera, however, or if the object moves after you preset the zoom lens, you need to calibrate the lens again.

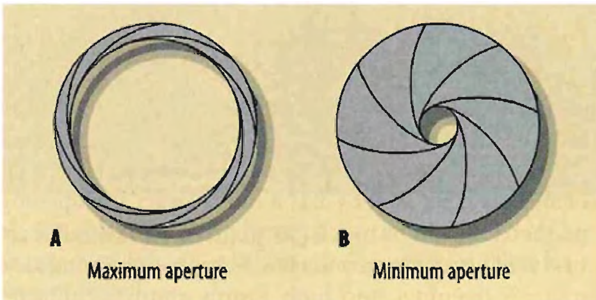
For example, if you had preset the zoom on the news anchor but then the director instructed you to move the camera a little closer and to the left so that she could more easily read the teleprompter, you would not be able to maintain focus without presetting the zoom again from the new position. If, after presetting the zoom, you were asked to zoom in on the map behind the news anchor, you would have to adjust the focus while zooming past the anchor—not an easy task for even an experienced camera operator.

If the camera moves are predetermined and repeated from show to show, as in a daily newscast, you can use the preset features of the digital zoom lens. The lens then remembers the various zoom positions and performs them automatically with the push of a button.

Unless you have an automatic focus control, you must preset the zoom on an ENG/EFP camera even when covering a news event in the field. You may have noticed that unedited video of a disaster (such as a tornado or fire) often contains brief out-of-focus close-ups followed by focusing and quick zoom-outs. What the camera operator is doing is calibrating the zoom lens to stay in focus during subsequent zoom-ins.



4.7 LENS IRIS
The iris, or lens diaphragm, consists of a series of thin metal blades that form, through partial overlapping, an aperture, or lens opening, of variable size.



4.8 MAXIMUM AND MINIMUM APERTURES
A At the maximum aperture, the iris blades form a large opening, permitting a great amount of light to enter the lens.
B At the minimum setting, the blades overlap to form a small hole, admitting only a small amount of light.

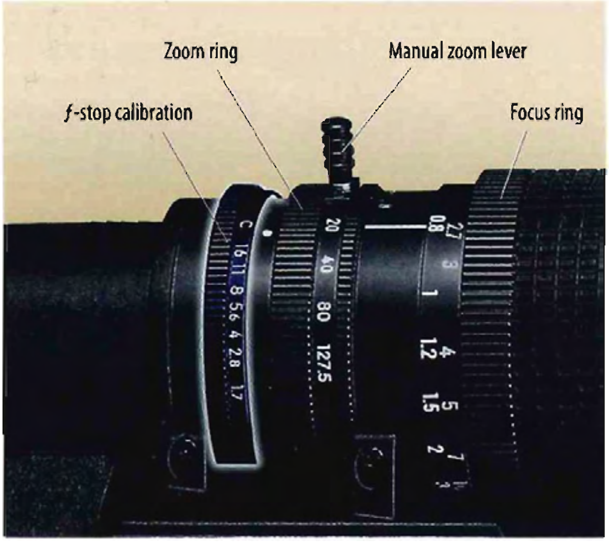
LIGHT TRANSMISSION: IRIS, APERTURE, AND *f*-STOP

Like the pupil in the human eye, all lenses have a mechanism that controls how much light is admitted through them. This mechanism is called the *iris* or *lens diaphragm*. The iris consists of a series of thin metal blades that form a fairly round hole—the *aperture*, or lens opening—of variable size. **SEE 4.7**

If you "open up" the lens as wide as it will go, or, technically, if you set the lens to its maximum aperture, it admits the maximum amount of light. **SEE 4.8A** If you close the lens somewhat, the metal blades of the iris form a smaller hole and less light passes through the lens. If you close the lens all the way—that is, if you set it to its minimum aperture—very little light is admitted. **SEE 4.8B** Some irises can be closed entirely, which means that no light at all goes through the lens.

***f*-stop** The standard scale that indicates how much light goes through a lens, regardless of the lens type, is the *f-stop*. **SEE 4.9** If, for example, you have two cameras—a camcorder with a 10× zoom lens and a field camera with a large 50× lens—and both lenses are set at *f*/5.6, the imaging devices in both cameras will receive an identical amount of light.

Regardless of camera type, *f*-stops are expressed in a series of numbers, such as *f*/1.7, *f*/2.8, *f*/4, *f*/5.6, *f*/8,



4.9 ƒ-STOP SETTINGS
The ƒ-stop is a calibration that indicates how large or small the aperture is.

ƒ/11, and ƒ/16 (see figure 4.9). The *lower* ƒ-stop numbers indicate a relatively *large* aperture or iris opening (lens is relatively wide open). The *higher* ƒ-stop numbers indicate a relatively *small* aperture (lens is closed down considerably). A lens that is set at ƒ/1.7 has a much larger iris opening and therefore admits much more light than one that is set at ƒ/16. (The reason why the low ƒ-stop numbers indicate large iris openings and high ƒ-stop numbers indicate relatively small iris openings, rather than the other way around, is that the ƒ-stop numbers actually express a ratio. In this sense ƒ/4 is actually ƒ/¼; that is, ƒ one over four.) As mentioned, most lenses produce the sharpest pictures between ƒ/5.6 and ƒ/8. Some lenses extend the optimal focus to ƒ/11.

Lens speed The "speed" of a lens has nothing to do with how fast it transmits light, but with how much light it lets through. A lens that allows a relatively great amount of light to enter is called a ***fast lens.*** Fast lenses go down to a small ƒ-stop number (such as ƒ/1.4). Most good studio zoom lenses open up to ƒ/1.6, which is fast enough to make the camera work properly even in low-light conditions.

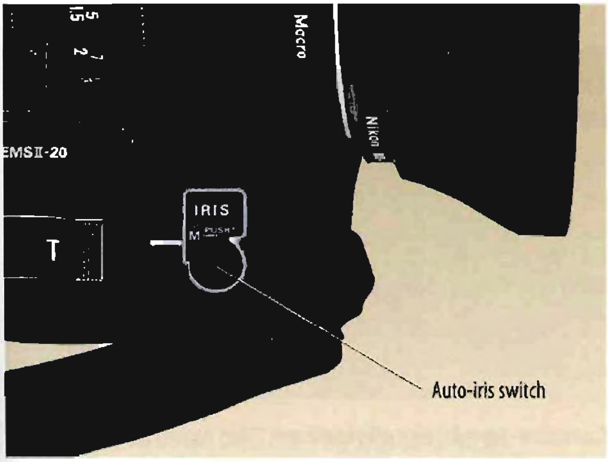
A lens that transmits relatively little light at the maximum iris aperture is called a ***slow lens.*** A studio lens whose lowest ƒ-stop is ƒ/2.8 is obviously slower than a lens that can open up to ƒ/1.7. Range extenders render the zoom lens inevitably slower. A 2× extender can reduce the lens speed by as much as two "stops" (higher ƒ-stop numbers), for instance, from ƒ/1.7 to ƒ/4 (see figure 4.9). This reduction in light transmission is not a big handicap, however, because range extenders are normally used outdoors, where there is enough light. The more serious problem is a slight deterioration of the original picture resolution.

Remote iris control Because the amount of light that strikes the camera's imaging device is so important for picture quality, the continuous adjustment of the iris is a fundamental function of video control. Studio cameras have a *remote iris control,* which means that the aperture can be continuously adjusted by the video operator (VO) from the camera control unit (CCU). If the set is properly lighted and the camera properly set up (electronically adjusted to the light/dark extremes of the scene), all that the VO has to do to maintain good pictures is work the remote iris control—open the iris in low-light conditions and close it down somewhat when there is more light than needed.

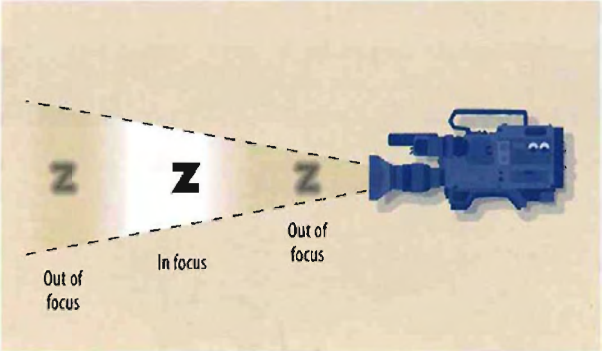
Auto-iris switch Most cameras, especially ENG/EFP and consumer camcorders, can be switched from the manual to the auto-iris mode. **SEE 4.10** The camera then senses the light entering the lens and automatically adjusts the iris for optimal camera performance. This auto-iris feature works well so long as the scene does not have too much contrast. There are circumstances, however, in which you may want to switch the camera over to manual iris control. For example, if you took a loose close-up shot of a woman wearing a white hat in bright sunlight, the automatic iris would adjust to the bright light of the white hat, not to the darker (shadowed) face under the hat. The auto-iris control would therefore give you a perfectly exposed hat but an underexposed face. In this case you would switch to manual iris control, zoom in on the face to eliminate most of the white hat, then adjust the iris to the light reflecting off the face rather than the hat. When switching to manual iris control, however, you will find that even a fairly good ENG/EFP camera can't handle such an extreme contrast. In this case you might try a *neutral density (ND) filter,* which would lower the extreme brightness without making the dense shadow areas any darker. (Other ways to handle extreme contrast are explained in chapter 8.) **ZVL2** CAMERA→ Exposure control→ aperture | ƒ-stop | auto iris | try it

DEPTH OF FIELD

If you place objects at different distances from the camera, some will be in focus and others will be out of focus. The area in which the objects are in focus is called ***depth of field.*** The depth of field can be shallow or great, but it is always greater behind the object than in front of it. **SEE 4.11**



4.10 AUTO-IRIS SWITCH
The auto-iris switch lets you change the aperture control from manual to automatic. You can quickly change back to manual simply by pressing the auto-iris switch without interrupting your shot.



4.11 DEPTH OF FIELD
The depth of field is the area within which all objects, although located at different distances from the camera, are in focus.

If you have a shallow depth of field and you focus on an object in the foreground, the middleground and background objects will be out of focus. **SEE 4.12** If the depth of field is great, all objects (foreground, middleground, and background) will be in focus, even though you focus on the middleground object only. **SEE 4.13**

With a great depth of field, there is a large "sharp zone" in which people or objects can move toward or away from the camera without going out of focus or without any need for adjusting the camera focus. If they move in a shallow depth of field, however, they can quickly become blurred unless you adjust the camera focus. A similar thing happens when you move the camera. A great depth of field makes it relatively easy to move the camera toward or away from the object because you do not have to work any controls to keep the picture in focus. If you move the camera similarly in a shallow depth of field, you must adjust the focus continuously to keep the target object sharp and clear.

Operationally, the depth of field depends on the coordination of three factors: (1) the focal length of the lens, (2) the aperture, and (3) the distance between the camera and the object.

4.12 SHALLOW DEPTH OF FIELD
With a shallow depth of field, the area in which an object is in focus is limited.

4.13 GREAT DEPTH OF FIELD
With a great depth of field, almost everything in the camera's field of view appears in focus.

Focal length The focal length of the lens is the factor that most influences the depth of field. In general, wide-angle lenses and, of course, wide-angle (short-focal-length) zoom positions (zoomed out) have a great depth of field. Narrow-angle lenses and narrow-angle (long-focal-length)

4.14 DEPTH-OF-FIELD FACTORS

DEPTH OF FIELD	FOCAL LENGTH	APERTURE	*f*-STOP	LIGHT LEVEL	SUBJECT/CAMERA DISTANCE
Great	Short (wide-angle)	Small	Large *f*-stop number (*f*/22)	High (bright light)	Far
Shallow	Long (narrow-angle)	Large	Small *f*-stop number (*f*/1.4)	Low (dim light)	Near

This chart was prepared by Michael Hopkinson of Lane Community College.

zoom positions (zoomed in) have a shallow depth of field. You may want to remember a simple rule of thumb:

- *Depth of field increases as focal length decreases.*

ENG EFP When running after a fast-moving news event, should you zoom all the way in or all the way out? *All the way out.* Why? Because, first, the wide-angle position of the zoom lens will at least show the viewer what is going on. Second, and most important, the resulting great depth of field will help keep most of your shots in focus, regardless of whether you are close to or far away from the event or whether you or the event is on the move.

Aperture Large iris openings cause a shallow depth of field; small iris openings cause a large depth of field. The rule of thumb for apertures is this:

- *Large f-stop numbers (such as f/16 or f/22) contribute to a great depth of field; small f-stop numbers (such as f/1.7 or f/2) contribute to a shallow depth of field.*

Here is an example of how everything in television production seems to influence everything else: If you have to work in low-light conditions, you need to open up the iris and thereby increase its aperture to get enough light for the camera. But this large aperture (low *f*-stop number) reduces the depth of field. Thus, if you are to cover a news story when it is getting dark and you have no time or opportunity to use artificial lighting, focus becomes critical—you are working in a shallow depth of field. This problem is compounded when zooming in to tight close-ups. On the other hand, in bright sunlight you can stop down (decrease the aperture) and thereby achieve a large depth of field. Now you can run with the camera or cover people who are moving toward or away from you without too much worry about staying in focus—provided the zoom lens is in a wide-angle position.

Camera-to-object distance The closer the camera is to the object, the shallower the depth of field. The farther the camera is from the object, the greater the depth of field. Camera-to-object distance also influences the focal-length effect on depth of field. For example, if you have a wide-angle lens (zoom lens in a wide-angle position), the depth of field is great. But as soon as you move the camera close to the object, the depth of field becomes shallow. The same is true in reverse: If you work with the zoom lens in a narrow-angle position (zoomed in), you have a shallow depth of field. But if the camera is focused on an object relatively far away from the camera (such as a field camera located high in the stands to cover an automobile race), you work in a fairly great depth of field and do not have to worry too much about adjusting focus, unless you zoom in to an extreme close-up. SEE 4.14

- *Generally, the depth of field is shallow when you work with close-ups and low-light conditions. The depth of field is great when you work with long shots and high light levels.* ZVL3 CAMERA→ Focusing→ focus ring | depth of field | great depth | shallow | rack focus | auto focus | try it

OPERATIONAL CONTROLS

You need two basic controls to operate a zoom lens: the *zoom control,* which lets you zoom out to a wide shot or zoom in to a close-up, and the *focus control,* which slides the lens elements that lie close to the front of the zoom lens back and forth until the image or a specific part of the image is sharp. Both controls can be operated manually or through a motor-driven servo control mechanism.

ZOOM CONTROL

Most zoom lenses of professional cameras are equipped with a servo mechanism whose motor activates the zoom, not comply. Also, if you do a fast zoom with a consumer camera, the automatic focus may not always be able to keep up; the picture will pop in and out of focus during the zoom. That is why manual focus devices are often preferred in critical camera work.

As mentioned previously, focusing an HDTV image is not always easy because the high resolution can fool you into believing that the picture is in focus. To help HDTV camera operators focus and stay in focus, some lenses have a built-in focus-assist feature. The camera operator can use a roller ball (similar to that of a computer mouse) to select the picture area that needs to be in sharp focus, and the focus system in the lens will do the rest. Obviously, this feature is not designed for the live HDTV coverage of sporting events.

MAIN POINTS

- There are various ways to classify zoom lenses: as studio and field lenses and according to zoom range and lens format.
- A range extender (an additional lens element) extends the telephoto power of the zoom lens (permits a closer shot) but reduces the range at the wide-angle end.
- The primary function of the lens is to produce a small, sharp optical image on the front surface of the camera's imaging device.
- All television cameras are equipped with zoom (variable-focal-length) lenses.
- The major optical characteristics of lenses are focal length, focus, light transmission (iris, aperture, and *f*-stop), and depth of field.
- The focal length of a lens determines how wide or narrow a vista the camera can show and how much and how close or far away the object seems to be from the camera (viewer). Zoom lenses have a variable focal length, whose major positions are wide-angle, normal, and narrow-angle (telephoto).
- A wide-angle lens (zoomed out) gives a wide vista. A narrow-angle lens (zoomed in) gives a narrow vista but magnifies the object so that it appears closer to the camera than it actually is. A normal lens (zoom position toward the midrange of the zoom) approximates the angle of human vision.
- A picture is in focus when the projected image is sharp and clear. The lens needs to be preset (calibrated) so that focus is maintained over the zoom range. If the lens is properly focused when zoomed in, it should remain in focus when zoomed out and in again.
- The lens iris, or diaphragm, controls the amount of light passing through the lens. It consists of a series of thin metal plates that form a hole known as the aperture, or lens opening.
- The *f*-stop is a standard scale indicating how much light passes through the lens. Low *f*-stop numbers indicate large apertures; high *f*-stop numbers indicate small apertures.
- Studio cameras have a remote iris control, which is operated by the VO (video operator) from the CCU (camera control unit). ENG/EFP cameras and consumer camcorders can be switched from manual to auto-iris control, whereby the lens adjusts itself for optimal exposure (amount of light reaching the imaging device).
- The area in which objects at different distances from the camera are seen in focus is called depth of field. The depth of field depends on the focal length of the lens, the aperture (*f*-stop), and the distance from camera to object.
- The two basic operational controls for the zoom lens are the zoom control and the focus control. On ENG/EFP cameras and camcorders, both can be operated either manually or automatically by servo control.
- A digital zoom lens can be programmed to repeat zoom positions and their corresponding focus settings.
- Digital zooming refers to the gradual enlarging of the center portion of the image. It usually extends the optical zoom.
- Auto-focus is an automated feature whereby the camera focuses on what it senses to be the target area. HDTV lenses have a focus-assist feature whereby the camera operator selects the target area.