A Jumpstart Guide for the Student Cinematographer

by Stephen H. Burum, ASC

I know many students will use this manual as a textbook for learning cinematography. However, it is first and foremost a reference for the working cinematographer who uses its tables and charts every day.

For many years I have felt that there should be a short, uncomplicated explanation of cinematography's basic underlying principles. Students should be able to start shooting right away, instead of reading or listening to arcane and complex treatises on photography.

The basics of cinematography are simple to grasp. They have been made this way by the tireless efforts of many scientists and working professionals who have created systems that ensure high-quality, repeatable results. The mathematical relationships in these systems are the keys to understanding how things work.

This brief article will quickly start you on the road to making pictures. Then when you have questions, the explanations and charts in this manual will provide the answers you seek.

It is the "art" of cinematography that is not so simple. This requires judgment, taste and experience.

So let's start at the beginning with the element that is essential to our art, light. Whether it's natural (the sun) or artificial (electric lights), light is described by its color and intensity.

Color is identified in photographic terms either by color temperature in degrees Kelvin or by Mireds. The higher the color temperature, the bluer the light. The lower the color temperature, the redder the light. For cinematographers, the two most useful values to remember are

Photographic Daylight Balance (5500°K) and Photographic Tungsten Balance (3200°K).

You'll also need to know the intensity of the light to determine your correct exposure. When you measure light bouncing off a subject, it is called Reflected Light and its intensity is measured in Foot Lamberts or Candles per square meter. Light falling onto the subject is called Incident Light and its intensity is measured in Foot Candles or Lux.

Light gets focused through a lens to form an image on film. Lenses have a first and last name (e.g., 75mm f1.4). The first name is its focal length in millimeters (mm). The second name is the maximum size its aperture will open to let in light (f1.4).

The focal length is the distance from the optical center of the lens to the film plane where an image is formed when focused at infinity.

The aperture is the hole that lets light into the lens. There are a prescribed series of aperture sizes, each with a different numeric value. When these sets of values are derived by using a mathematical ratio between the size of the hole and the focal length of the lens, they are called f-stops. If these values are calibrated by measuring the light transmitted through the lens they are called T-stops. Each of these values have the same function of describing the change in the amount of light from one stop to another. Each stop change either doubles or halves the light. Both f- and T-stops are the same for our purpose. These numbers have been standardized and their full value has been rounded off to the following numbers we see engraved on our lens. Starting at the biggest hole and proceeding to the smallest hole, they are: 1.4, 2, 2.8, 4, 5.6, 8, 11, 16 and 22.

Every lens has a set of characteristics: Its Angle of View is how much the lens sees of both its horizontal and vertical angles. Its Depth of Field is the distance between points nearest to and farthest from the camera that look sharp. To get more depth of field you need to use a smaller format, smaller aperture, shorter focal length or move the point of focus farther from camera. For less depth of field use a larger format, bigger aperture, longer focal length or move the point of focus closer to camera. The lens's perspective drawing shows the three-dimensional relationship of the distance and depth between objects in the frame. These characteristics work together and can be altered for dramatic effect by using lenses with different focal lengths.

The Normal Lens is one that creates a perspective similar to human vision so that the distance between objects appears as a human would see it.

Each film size or format has a corresponding normal lens which is said to have a focal length equal to the diagonal of the format. In full frame (full aperture) 35mm motion picture photography, the normal lens's focal length is about 32mm, and in the 16mm format it's about 13mm.

Lenses with a focal length of less than normal are called either Short or Wide-Angle lenses. Lenses with a greater than normal focal length are called Long or Telephoto lenses.

When placed side by side, the wide-angle lens sees more area at the same distance than a normal lens. The long lens sees less area at this distance than either the wide-angle or normal lenses.

By using different focal lengths, the size relationship between objects in the frame can be altered. If you keep the distance between two objects the same, and the foreground object the same size with each different lens, you will notice that using a wide angle lens the background object will appear smaller than if you used a normal lens. If you use a telephoto lens you will see that the foreground and background objects appear to be very close to the same size. The impression that different lenses have different perspective drawings is a function of its angle of view. (See chapter on lenses, page 151, table on angle of view, page 754, tables on depth of field page 718.)

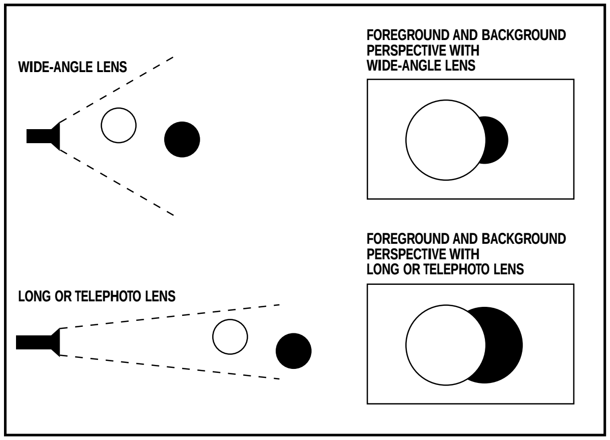

Figure 1. Illustration of lens and field size and perspective drawing.

Black-and-White Film

Pictures are formed by light being focused onto a clear flexible film coated with silver halide. This material is light-sensitive. When the film is developed, the silver is left on the film base in the same proportion as the amount of light striking it. The brighter the subject, the more silver is left; the darker the subject, the less silver is left. The exposed silver forms a negative or reverse image. To see the correct tonal representation of the scene, a positive print must be made from the negative.

Color Film

Color pictures are made by using three layers of black-and-white emulsion. Each layer is made sensitive to only one of the three primary colors of light: Red, Green, and Blue. Each of these layers contains a different color dye that couples with the exposed silver to reproduce the colors we see.

Electronic Photography

Instead of changing chemicals into silver and dye, light is focused onto a light-sensitive tube or chip that changes light into electricity. These voltages are translated through circuitry to produce pictures. (See ASC Video manual.)

Color Theory

Both color and panchromatic black-and-white film are sensitive to the three primary colors of light: Red, Green, and Blue. There are also three complementary or opposite colors: Cyan, Magenta, and Yellow. Please note their relationship in the chart below:

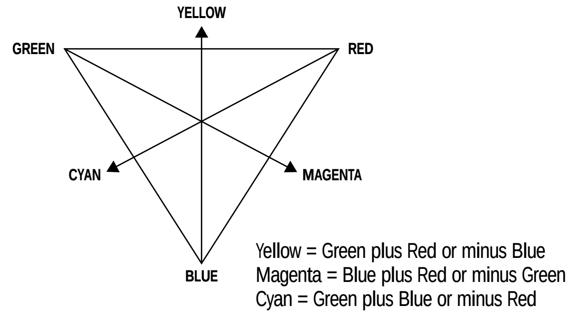

Figure 2. Color Triangle.

If you place a colored filter over your camera lens it will block out the light of its complement. For example, a yellow filter will only transmit red and green light, and will block the blue light. Blocking or subtracting colors is the keystone of black-and-white contrast and tonal control. It is also the basis of color correction in color photography. Filters require an exposure increase because of light loss. Special colorless (neutral) filters used to reduce exposure are called Neutral Density or ND filters.The amount of increase is indicated by the filter factor. (See Filters chapter page 193, Laboratory chapter page 99, Kodak Publications H-1, B-3, H-188 and KW-13.)

Filter Factors

Equivalent F-Stop Corrections for Filter Factors			
Filter Factor	Increase In Stops	Filter Factor	Increase In Stops
1.25	+ $^1/_3$	8	+ 3
1.5	+ $^2/_3$	10	+ 3 $^1/_3$
2	+ 1	12	+ 3 $^2/_3$
2.5	+ 1 $^1/_3$	16	+ 4
3	+ 1 $^2/_3$	40	+ 5 $^1/_3$
4	+ 2	100	+ 6 $^2/_3$
5	+ 2 $^1/_3$	1000	+ 10
6	+ 2 $^2/_3$		

Figure 3. Filter Factors are in $^1/_3$ stops.

Neutral Density Filters

Kodak Wratten Neutral Density Filter No. 96			
Neutral Density	Percent Transmittance	Filter Factor	Increase in Exposure (Stops)
0.1	80	1.25	$^1/_3$
0.2	63	1.5	$^2/_3$
0.3	50	2	1
0.4	40	2.5	1 $^1/_3$
0.5	32	3	1 2/3
0.6	25	4	2
0.7	20	5	2 $^1/_3$
0.8	16	6	2 $^2/_3$
0.9	13	8	3
1.0	10	10	3 $^1/_3$
2.0	1	100	6 $^2/_3$
3.0	0.1	1,000	10
4.0	0.01	10,000	13 $^1/_3$

Figure 4. Neutral density filters are graded in $^1/_3$ stops.

Film Speed

Every film stock requires a specific amount of light to make its best picture. Film manufacturers have a rating system called an Exposure Index, or EI, that tells you what this quantity of light will be. The higher the number, the less light is required. This number is also referred to as ASA, ISO,

EI/ASA				
6	**25**	**100**	**400**	**1600**
8	32	125	500	2000
10	40	160	640	2500
12	**50**	**200**	**800**	**3200**
16	64	250	1000	4000
20	80	320	1250	5000

Figure 5. EI/ASA. Film speed ratings are in ⅓ stops.

or, in Europe, DIN. It can be found on the film label.

Each one of these numbers changes the exposure ⅓ of a stop. (See Kodak publication Z-22ED *Basic Photographic Sensitometry Workbook*.)

F-stop and T-stop numbers represent a relationship of how much light you are letting into or cutting out of the lens. Each stop either doubles or halves the light. If you open up one stop [bigger hole, smaller number], you let in twice as much light. If you close down one stop [smaller hole, bigger number], you cut the light falling on the film by one half. When you open up or close down by more than one stop, you multiply the doubling and halving effect.

F/T-Stop Relations

	Open	Closed
1 Stop	2 x 1 = 2	$\frac{1}{2}$ x 1 = $\frac{1}{2}$
2 Stops	2 x 2 = 4	$\frac{1}{2}$ x $\frac{1}{2}$ = $\frac{1}{4}$
3 Stops	2 x 2 x 2 = 8	$\frac{1}{2}$ x $\frac{1}{2}$ x $\frac{1}{2}$ = $\frac{1}{8}$
4 Stops	2 x 2 x 2 x 2 = 16	$\frac{1}{2}$ x $\frac{1}{2}$ x $\frac{1}{2}$ x $\frac{1}{2}$ = $\frac{1}{16}$

Figure 6. F/T-Stop Relations

The relationships of all these variables can be correlated, so you can move between values to fine-tune your exposure system. They all use the common unit of ⅓ stop of exposure.

Exposure time has two components: the angle of the shutter opening expressed in degrees, and the number of frames that pass by the camera aperture in frames per

F/T-Stops in ⅓ Stops							
Full Stops	**1.4**			**2**			
1/3 Stops		1.6	1.8		2.2	2.5	
Full Stops	**2.8**			**4**			
1/3 Stops		3.2	3.5		4.5	5	
Full Stops	**5.6**			**8**			
1/3 Stops		6.3	7		9	10	
Full Stops	**11**			**16**			**22**
1/3 Stops		12.7	14		18	20	

Figure 7. F/T-Stops in ⅓ stops.

second. Sound movie cameras run at 24 frames per second, at a standard shutter opening from about 170 degrees to 200 degrees. To get the exposure time in fractions of a second, simply double the frame rate. In the case of 24 fps it would be 1⁄48 of a second, but it is always rounded off to 1⁄50 of a second. If you alter the shutter opening or the frame rate, your exposure time will change. (See charts pages 869 through 871, Kodak Publication V3-1635.)

Charts relating to the number of footcandles needed for a particular exposure index (EI, ASA, ISO) at a certain f-stop are arranged in ⅓ stop increments. (See charts, pages 864–865.)

Some film facts:

Size of film	Frames per foot	Feet per minute at 24 fps
Super 8mm	72	20
16mm	40	36
35mm	16	90
65/70mm	12.8	112 feet + 6.4 frames
VistaVision (sideways 35mm double frame)	8	180

The Camera

All movie cameras have the following components: 1. a lens that can focus with a changeable f-stop; 2. a light tight box; 3. a shutter to black out the film while it moves to the next frame; 4. an intermittent movement to hold motionless and register the film for a split second exposure; 5. a film transport to move the film through the camera; 6. a magazine to hold the film; 7. a viewing system that is either reflex (looking through the lens), Non reflex (looking through an external finder), or electronic (a little TV screen).

The camera can be mounted on several types of moveable heads that can pan and tilt the camera; 1. friction head; 2. gear head; 3. fluid head; 4. remote head; 5. third axis head. The camera and head are then mounted on: 1.tripod; 2. dolly (wheeled platform to move camera); 3.crane (teeter totter device to move the camera up and down); 4. self-leveling gimbal base; 5. special mounts lashed to cars, boats, and planes; 6. a self stabilizing mount, like a Steadicam. Finally, you can just hold the camera by itself (hand held), or put it on the ground. (See chapter on cameras page 489, chapter on mounting devices page 225.)

Getting Started

Now let's put together what we need to know to start shooting. Is your film color balanced for daylight or tungsten? Most professional color movie film is balanced for tungsten. If you are shooting under a daylight source (sunlight, arcs, HMI, daylight fluorescent tubes, or color-corrected tungsten light), you will need to put a filter on the film to get the proper color balance. To convert tungsten-balanced color film (3200°K) to daylight balance (5500°K) use the Wratten number 85 filter. If your light source is tungsten-balanced, then just shoot away. For black-and-white film, choose the EI that represents your light condition. No color temperature correction is necessary, but you may want to use a contrast-control filter. As noted earlier, each film stock has a film sensitivity (speed) rating called the exposure index (EI, ASA, ISO, or DIN). You will find this information on the film can along with the color balance.

Set your light meter to the correct EI rating that is on the film can label. You will notice that there are two EIs, one for daylight and one for tungsten. Your meter also has a series of exposure times marked as shutter speeds. If you are shooting at sound speed, your exposure will be 1⁄50 of a second. Next, if you have a reflective meter, point it at the scene from the camera. If you have an incident meter, stand at your subject and point it at the camera. If you have no meter, and you are outside on a bright sunshiny day, use the still photography f16 rule: which states that if your subject is in full front light, and you set your shutter speed (exposure time) at the EI of the film, the f-stop will be f16. You know that for sound movies the shutter speed (exposure time) is a constant 1⁄50. If your EI is 50 your lens can be set at f16. If your EI is different simply use the tables in this manual to come up with the correct exposure. (See chapter on light meters page 63.)

Lighting Basics

Making two-dimensional works of art (such as paintings, still photographs and motion pictures) appear three-dimensional is done by using classic lighting techniques developed by artists over the years.

First, cast a shadow. This gives your subject form and texture. The edge of the shadow is defined by the light source you use. A pinpoint source gives a sharp edge similar to the sun. A large area source makes a soft diffused edge that almost melts away as on an overcast day. There are many gradations in-between. The light source is called the keylight.

To create depth, you must separate one object from another (people from walls, etc.). This can only be done by contrasting light against dark or dark against light. This is true whether you work in black-and-white or color. The lights used to do this are called back lights, kickers, rims, liners, and glow lights.

In order to create a mood, you must control the detail in the shadows you've cast by adding or subtracting light from these shadows. This is called fill light.

Exposure is always determined by reading the value of the key light. The other lights are judged by eye against the value of the key light.

The volume of lights and darks you put in the frame will help you set the time and mood of the story (e.g., lots of dark tones for night, lots of light tones for day. The time of day and season of the year are indicated by the angle of the sun. At sunrise and sunset we know that the light is low on the horizon, and at noon it is the highest overhead. We also know that the noon sun is lower in the Winter and higher in the Summer.

Finally, if you want your picture to look rich, and have a full range of values, each frame needs a black reference, a white reference, and a key or middle-gray reference. These may be only small portions of the screen, but if they are missing, your scene will look flat and uninteresting. This is especially true for black-and-white. (See *Reflections: 21 Cinematographers at Work*, by Benjamin Bergery.)

Testing for the cinematographer is like practice for a dancer or rehearsal for an actor: the more you do it the better you get. There is no substitute for the knowledge and understanding you get from testing. All of the voluminous books and charts are only a starting point for learning the art and craft of cinematography. So let's get to work. (See Testing page 112 and 121.)

Stephen H. Burum, ASC is a member of the ASC Board of Governors. Among his many credits are the feature films Rumblefish, The Untouchables, Mission Impossible, Mission to Mars, *and* Hoffa, *for which he received an Academy Award nomination in 1993.*