# CINEMATOGRAPHY RESOURCES:

## *LENS FORMULAS*

**All numbers used in this formula, and all others listed MUST be in the same units, i.e. millimeters, inches, etc. This excludes f-stop because it has no dimensions, and therefore always stays the same**

# WHEN SHOULD YOU CALCULATE DEPTH OF FIELD?

This is the most commonly asked for number from clients.

Use when they want to know how much of the foreground will be in focus, when you want a shallow depth of field, and need to know how much your subject can move within that depth of field, or when you want to figure out how much of the foreground will be in focus.

# WHEN SHOULD YOU USE HYPERFOCAL DISTANCE?

Hyperfocal distance, at its simplest, is the focusing distance that gives your photos the greatest depth of field. For example, consider a landscape where you want everything — foreground and background — to appear sharp. If you focus on the foreground, the background will appear blurry in the image.

Use hyperfocal distance when you want the entire scene to be acceptably sharp. For example, you may be photographing a scene that has elements in the foreground (not very close to the lens) and the background that you want to be in focus. By focusing at hyperfocal distance, you get these objects acceptably sharp in your image.

# DEPTH OF FIELD VS DEPTH OF FOCUS

Simply put, depth of FIELD concerns the image quality of a stationary lens as an object is repositioned, whereas depth of FOCUS concerns a stationary object and a sensor's ability to maintain focus for different sensor positions, including tilt.

The more distant you are from your subject, the wider or larger the depth of field. As a result, the depth of focus is shorter.

# ESSENTIALS

## HYPERFOCAL DISTANCE

The precise focus distance at which you get the maximum depth of field for a given aperture and focal length combination!

**H = (F^(2))/(fCc)**

Where

**H = hyperfocal distance**

**f = f-stop of lens**

**Cc = circle of confusion**

In order to calculate hyperfocal distance, you need to know three things:

1. Focal length – This will depend on what lens you're using.
2. Circle of confusion value – Commonly 0.03 and 0.02; depends on sensor type.
3. F-stop – f/2, f/11, etc

*More on circle of confusion: For circle of confusion consult the lens and camera manuals. You can also use .0010 inches (1/1000) as a conservative circle of confusion, although modern cine lenses may have an even smaller circle of confusion.*

<u>Example</u>

*Question:* Imagine you have a 20mm lens at f/11 on a full-frame camera, what is the hyperfocal distance?

*Answer:* Hyperfocal distance = (20 x 20) / (0.03 x 11) = 400/0.33 = 1212.12mm

So, you get a hyperfocal distance of 1212 mm, or 1.2 meters (almost 4 feet). You should focus on an object that is approximately 1.2 meters away; everything from 0.6 meters (half the hyperfocal distance) away to infinity will be in focus.

## DEPTH OF FIELD

*NOTE: There are numerous ways of writing these equations. Below are the equations as given in the ASC Handbook*

The range in front of and behind a designated focusing distance, where an object still appears to be in acceptable focus.

There are two equations for calculating depth of field, one for the far limit, and one for the near limit.

Camera to Near Limit: Dn = (H)(S)/((H=+(S-F))

Camera to Far Limit: Df = (H)(S)/((H=-(S-F))

**Total depth of field = Df-Dn**

where

**Dn = camera to near limit**

**Df = camera to far limit**

**H = hyperfocal distance**

**S = distance from camera to subject**

**F = focal length of lens**

Example

*Question:* A 35mm camera lens of 50 mm focal length is focused at 20 feet and is set to f/2.8. Over what range of distances will objects be in acceptable focus?

*Answer:*

1. First convert all units to the same system.

50 mm becomes 1.969 inches (rounding up to 2 inches is sufficient)

20 feet becomes 240 inches.

35 mm cameras have a circle of confusion equal to .001 inches.

2. Now calculate the hyperfocal distance

H = (F^(2))/(fCc)

H = ((2)(2))/((2.8)(0.001))

H = 4/0.0028

H = about 1,429 inches

3. Use the near and far equations to get the depth of field

Dn = ((1429)(240))/((1429+(240-2))

Df = ((1429)(240))/((1429-(240-2))

Dn = 205.7 inches (17.1 feet)

Df = 288 inches = (24 feet)

Therefore, when a 50 mm lens at 4/2.8 is focused at 20 feet, everything from 17.1 feet to 24 feet will be in acceptable focus.

## APPROX. DEPTH OF FIELD

**Dn = (HS)/(H+S)**

**Df = (HS)/(H-S)**

where

**Dn = camera to near limit**

**D*f* = camera to far limit**

**H = hyperfocal distance**

**S = distance from camera to subject**

**F = focal length of lens**

## TOTAL DEPTH OF FIELD

**Total depth of field = Df-Dn**

where

**Dn = camera to near limit**

**D*f* = camera to far limit**

## FINDING LENS SETTINGS WHEN DN AND DƑ ARE KNOWN

Use this to calculate the lens settings needed to accommodate for a set near and far focal length.

**Ls = ((2)(Dn)(D*f*))/ (Dn+D*f*)**

**H = ((2)(Dn)(D*f*))/ (Dn-D*f*)**

**f = (F^2)/((H)(Cc))**

Where

**Dn = camera to near limit**

**D*f* = camera to far limit**

**H = hyperfocal distance**

**Ls = Lens focus distance setting**

**F = focal length of lens**

***f*** **= f-stop setting of lens**

**Cc = circle of confusion**

<u>Example</u>

*Question:* a scene is being photographed on a 35mm camera using a 75mm lens. Everything in the scene from 15 to 27 feet must be in acceptable focus. How much the lens f-stop and focus be set?

*Answer:*

1. First convert all distances and focal lengths to inches

Focal length is 2.95 inches (75/25.40)

Dn is 180 inches (15×12)

Df is 324 inches (27×12)

2. Calculate!

Ls = focus distance setting = ((2)(180)(324))/(180+324) = 231 inches = 19.3 feet is your lens focus distance!

H = hyperfocal distance = (2.953^2)/(1429+(240-2)) = 810 inches = 67.5 feet is your hyperfocal distance

*f* = f-stop =(2.953^2)/(0.001×810) = f/10.77 = F/11 is your f-stop/aperture

## FRAME RATE, SHUTTER ANGLE AND EXPOSURE TIME RELATIONSHIP

**Te = 1/((Sx360)/a)**

**a = 360STe**

where

**a = shutter angle (in degrees)**

**S = frames per second**

**Te = exposure time (in seconds)**

Example

*Question:* What is the exposure time when shooting at 24 fps with a 180 degree shutter?

*Answer:*

Te = 1/((24×360)/180) = 1/48 second

## SIZE RELATIONSHIPS

*This equation only applies to spherical lenses*

**O/A = D/F**

Or

**D = distance to subject = (OF)/A**

**O = size of subject being photographed = (AD)/F**

**F = focal length of lens = (AD)/O**

**A = aperture size = (OF)/D**

Where

**F = focal length of lens**

**D = distance to object being photographed**

**O = size of object being photographed**

**A = aperture size**

**θ = viewing angle**

**To solve it simply input any three known variables.**

# MORE FORMULAS

## DEPTH OF FOCUS

The following equation is a good approximation of the depth of focus of a lens. This is most often used with film, because it refers to distance between the lens and the actual film plane.

**Depth of focus approximately = (F*f*)/1000**

Where

**F = focal length of lens (in mm)**

***f* = f-stop of lens**

<u>Example</u>

A 50 mm f/2.8 lens has the following depth of focus

(50×2.8)/1000 = 0.14mm = 0.0055 inches

So we know the film must stay within plus or minus half that value.

## F-STOP

This equation is helpful to know, but not as commonly used.

**$f = F/Da$**

Where

**$f$ = f-stop value of lens**

**F = focal length of lens**

**Da = diameter of aperture**

## FRAME RATES FOR MINIATURES

To make action in miniatures look convincing at normal speed, you usually need to shoot in a faster frame rate.

**$Rf = 24\sqrt{(1/s)}$**

where

**Rf = frame rate**

**S = scale of miniature**

<u>Example</u>

*Question:* What frame rate should be used to shoot a 1:4 (quarter scale) miniature?

*Answer:*

$Rf = 24\sqrt{(1/0.25)} = 24\sqrt{4} = 24\times2 = 48$ fps!

# FILM FORMULAS

## CALCULATE THE AMOUNT OF FILM NEEDED TO SHOOT FOR A CERTAIN TIME

These equations can only used when working with actual rolls of film

**Footage vs Time relationship equation**

**$Tf = (S)(t)$**

Where

**$Tf$ = total footage**

**$S$ = speed of film (in ft/min)**

**$t$ = time (in minutes)**

Get the speed of film using the film gage and frames per foot. Usually you can Google it.

<u>Example</u>

*Question:* How many feet of 35 mm film runs through a sound camera in 4 and a half minutes?

*Answer:*

Tf = 90×4.5

Tf = 405 feet of film needed to shoot 4 and a half minutes

## FOOTAGE IN FEET AND FRAMES EQUATION

**Ft = ((t)(Fs))/Ff**

Where

**Ft = total footage**

**Fs = frames per second**

**t = time (in seconds)**

**Ff =frames per foot (look this number up, it depends on the type of film camera and the film gage. Find a chart.)**

<u>Example</u>

*Question:* How much film goes through a 16mm sound camera in 8 seconds?

*Answer:*

Ft = (8×24)/40 = 4.8 feet

To convert to frames, multiply the decimal part by number of frames per foot.

.8×40 = 32 frames

Therefore the answer is 4 feet 32 frames goes through the camera in 8 seconds.

# QUESTIONS ANSWERED

## APERTURE VS F-STOP

People often use the terms “aperture” and “f-stop” interchangeably, but they are, in fact, two very different, but related, measures.

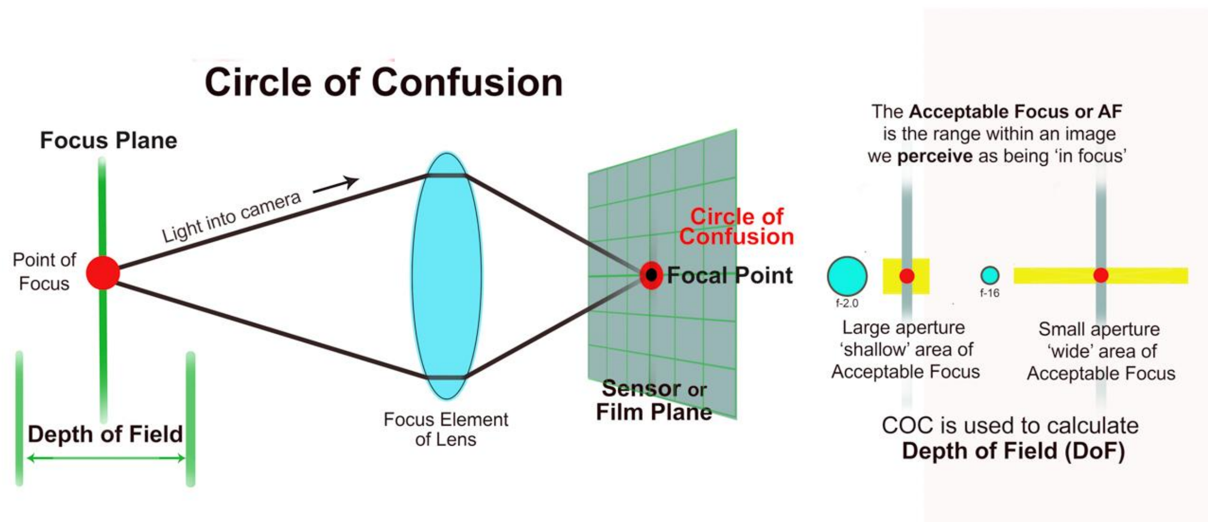
The “aperture” is the diameter of the entrance pupil of the lens, and is measures in mm.

The “f-stop” is the ratio of the focal length and the aperture diameter: f-stop = focal length / aperture diameter.

The aperture, in combination with shutter speed, determines how much total light that reaches the sensor. This is of central importance because it is the total light, along with sensor efficiency, that determines the total image noise (not ISO or sensor size, as most people think). The f-stop, on the other hand, determines the intensity of the light falling on the sensor, and, in combination, determines the density of light falling on the sensor. This is important, because the density of the light is the exposure.

## CIRCLE OF CONFUSION

Circle of Confusion (Cc) characterizes the degree of acceptable focus. The smaller the circle of confusion is the higher the resulting image sharpness.




Technically it is an optical spot caused by a cone of light rays from a lens not coming to a perfect focus when imaging a point source. It is also known as disk of confusion, circle of indistinctness, blur circle, or blur spot.

## 35MM EQUIVALENT FOCAL LENGTH

The term 35mm equivalent focal length is a comparison of the field of view seen through a digital camera lens compared to the field of view produced by the older 35mm film cameras.

The light capturing area (imaging area) of most digital camera image sensors is smaller than the imaging area of film.

The widest field of view is produced when 35mm film or a full frame image sensor is used. With each smaller sized image sensor, more of the outer areas of the scene are lost. (cropped)

The field of view from a 35mm film camera and its lens is the standard field of view to which digital camera fields of view are compared. That is why you will see the phrase 35mm equivalent used.

The bottom line is that the standard fields of view from 35mm cameras can be duplicated by digital cameras with their smaller sensors and lenses by using wider focal length lenses.

Calculating the 35mm focal length equivalent of a camera lens is done by using a number that is called the crop factor or the focal length multiplier. The crop factor or focal length multiplier represents the ratio of the size of an image sensor compared to 35mm film.

Simply multiply the focal length by the crop factor. Find the crop factor in your camera's manual.

**35mm equivalent focal length = (Digital Camera Lens Focal Length)(crop factor)**

Example

*Question:* 35mm equivalent focal length = (18mm)(1.5)

*Answer:* 35mm equivalent focal length = 27mm