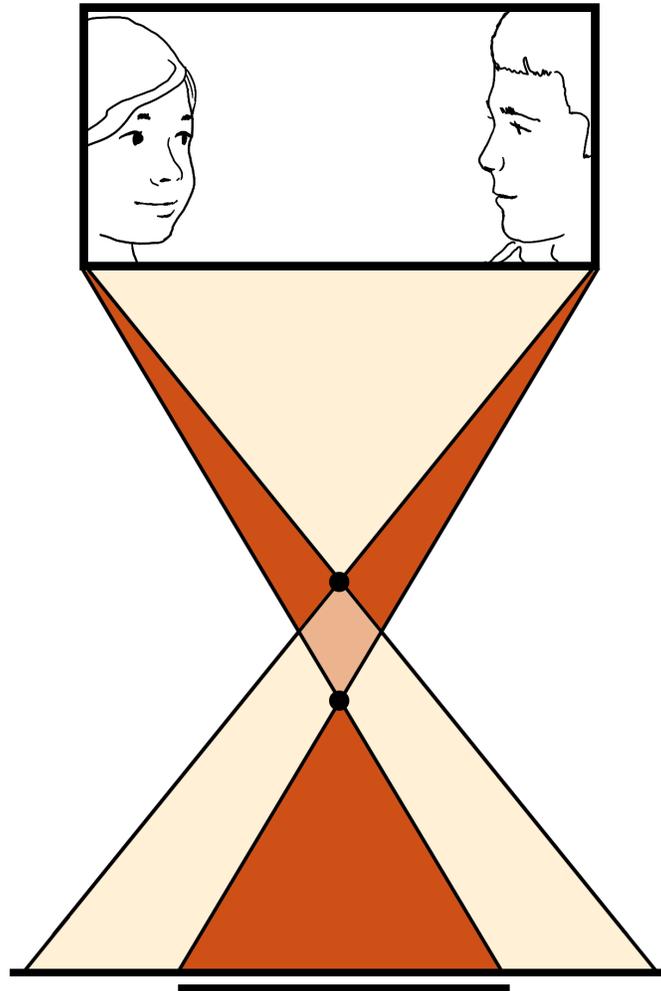


PRIMO 70 SERIES



Sensor Size & Field of View



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BASIC LENS CONCEPTS

To understand the use of lenses with different sensor sizes, we need to review some basic lens concepts:

SENSOR DIMENSIONS

Different digital cameras have different sensor sizes. The width and height of the sensor will determine the Field Of View, and will be used to calculate the Crop Factor.

FOCAL LENGTH

The focal length of a lens will **never change**, regardless of the sensor used. The focal length is the distance in millimeters, from the point where light rays converge in a lens to the digital sensor (or film). It defines many of the lens' characteristics, including **Perspective** and magnification.

The combination of Sensor Size and Focal Length will change the **Angle of View** and the **Field Of View**.

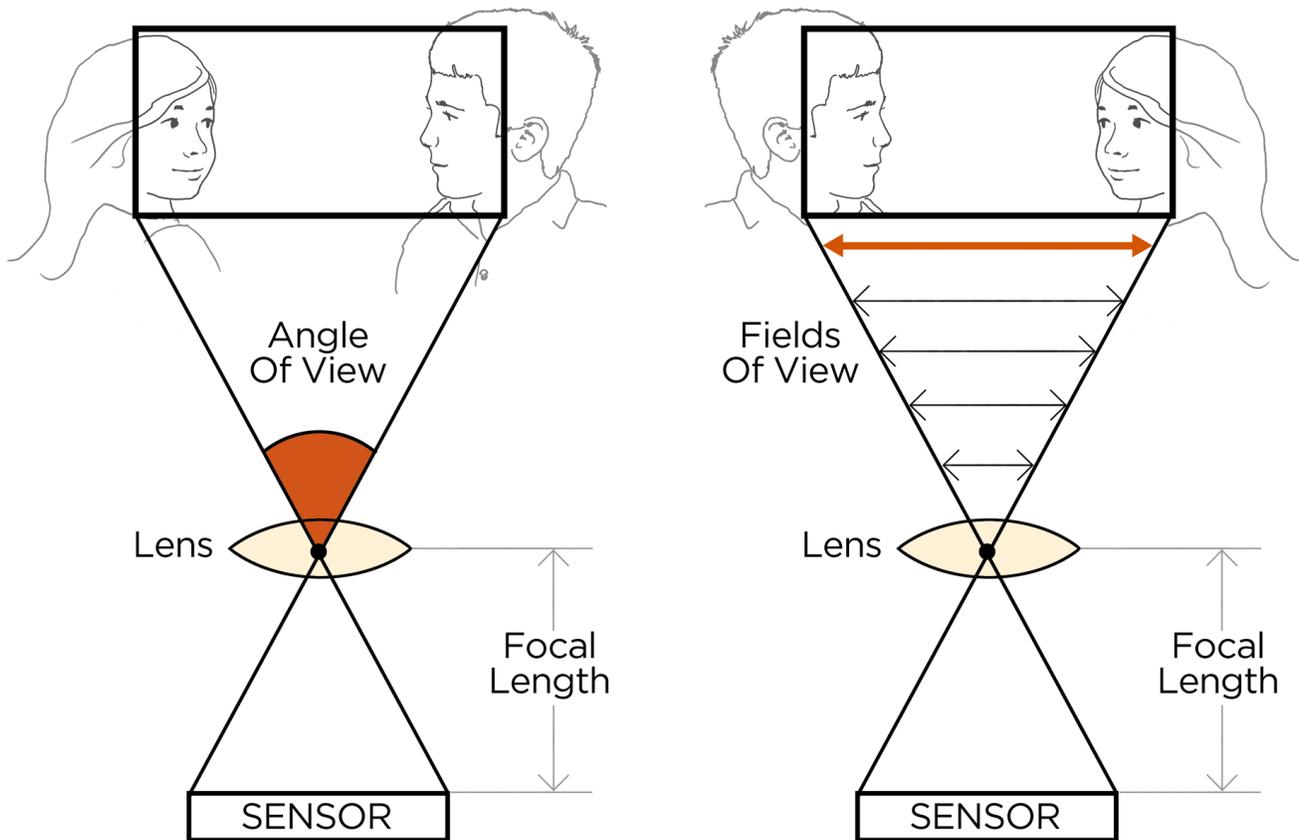
ANGLE OF VIEW

This is a measure of the vantage point from the lens. A short focal length will give you a wide angle of view, taking in more of the image than the narrow angle created by a long focal length lens.

FIELD OF VIEW (or FOV)

We are using Field of View to mean the length that the lens will **cover** at a certain distance. The FOV can be measured horizontally, vertically or diagonally. Our examples are of the **Horizontal** Field Of View. Shorter focal lengths will have a wider FOV than longer focal lengths. The horizontal and vertical fields of view define the **frame lines** at a given distance.

(Note that some people use Field of View to mean the same thing as Angle of View).

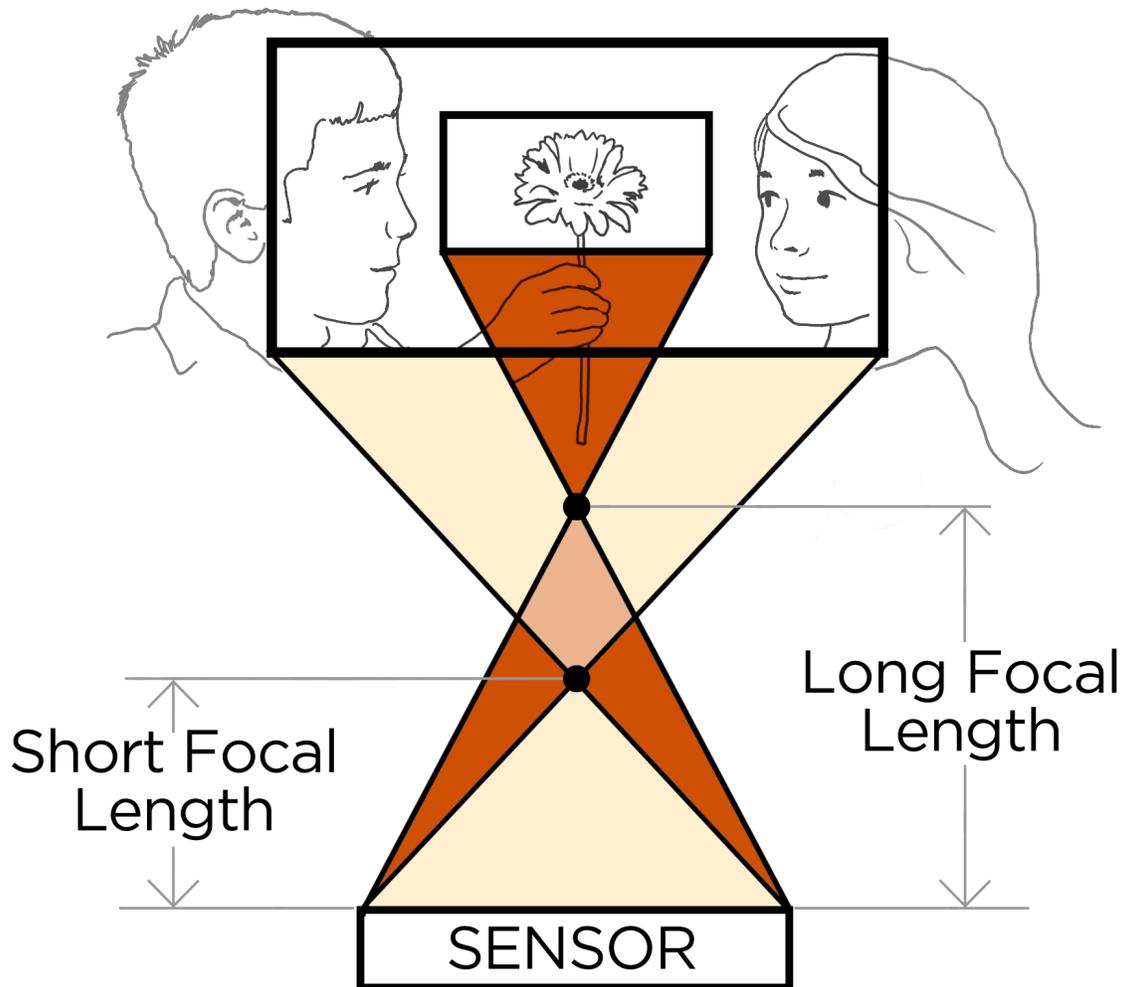


ANGLE OF VIEW VERSUS FIELD OF VIEW

The Angle of View remains **constant** for a given sensor and lens, the Field of View **varies** with the distance of the subject being filmed. Angle of View and Field of View define each other; you can use one to calculate the other.

The **Angle of View** (in burnt orange on the left) is defined at the lens position. Simple director's viewfinders change the Angle of View to simulate what different lenses will cover.

The **Field of View** is the horizontal (or vertical or diagonal) length of the image at a given distance from the lens. The right-hand diagram illustrates different Fields of View at different distances from the lens. Filmmakers are usually interested in the Field of View at the distance where actors are standing. The horizontal and vertical Fields of View define the **frame** at a given distance.



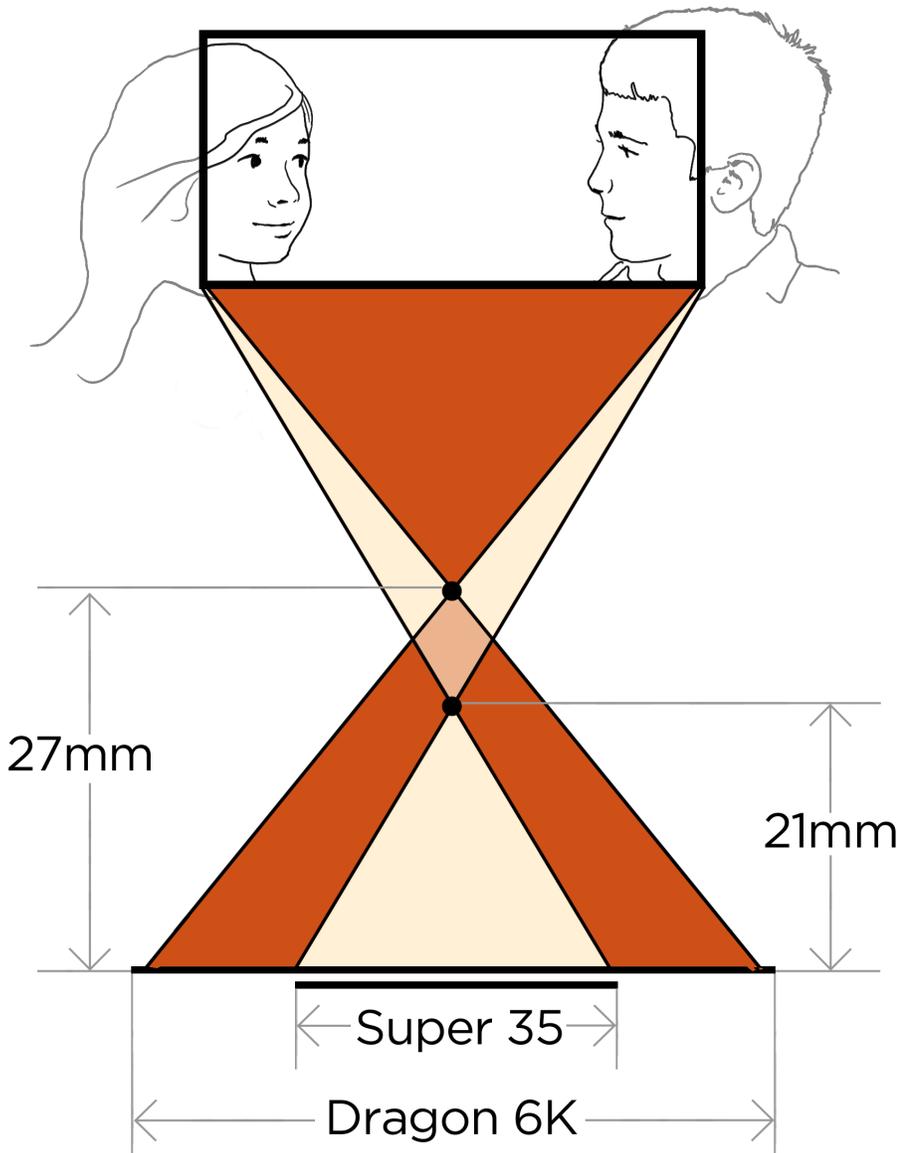
For a given Sensor Width, the short focal length will have a wide horizontal Field Of View (in yellow) and the long focal length will have a narrow FOV (burnt orange). The same diagram could be done for the Vertical or Diagonal FOV.

DEPTH OF FIELD

This is how much will be in focus at a given distance. The depth of field depends on Focal Length and T-Stop, as well as the circle of confusion, and more complex elements like the lighting and contrast of a scene. But all other things being equal, longer focal lengths will have less depth of field than shorter focal lengths, and larger iris apertures (e.g. T2) will have less depth of field than smaller ones (e.g. T4).

FIELD OF VIEW CHANGES WITH SENSOR SIZE

Many filmmakers know from **experience** what Field Of View different lenses will cover when shooting with Super 35. So one way to explain shooting with a bigger sensor is to tell filmmakers **which lens will have the same FOV on a Super 35 sensor**. Let's look at 2 different sensor sizes at the same camera position.



To get the **same Field Of View (FOV)** on a smaller sensor, you need a shorter focal length.

Here the **Dragon 6K horizontal FOV** is in burnt orange, and the **Super 35 horizontal FOV** is in yellow. They both frame **the same image**.

This example shows that a **27mm lens** on the **Dragon 6K** has the same FOV as a **21mm lens** on **Super 35**.

HOW TO CALCULATE & USE CROP FACTOR

The **Crop Factor** is a term that was first developed by stills photographers, to compare the angles of view of different formats with respect to 35mm stills cameras. We will use it with respect to the Super 35 motion picture format. The goal here is to find which 2 lenses have the same Field Of View with 2 different sensor sizes.

To find the lens on **sensor B** that has the same FOV as a lens on **sensor A**:

- Divide a dimension (height, width or diagonal) of sensor B by that of A. The result is the **Crop Factor** from sensor A to sensor B
- Multiply the focal length of the lens on sensor A by the Crop Factor. The result is the **lens on sensor B** that will have the same FOV.

Here's an **example**, using the sensor dimensions on the following page:

- Calculating Crop Factor to go **from** Dragon 6K **to** Super 35 in **2.39:1**

Dragon 6K Horizontal width in 2.39:1 = 30.70 mm

Super35 Horizontal width in 2.39:1 = 24 mm

Crop Factor = Super 35 / Dragon H

Crop Factor = $24 / 30.70 = \mathbf{0.78}$

- I have a 27mm on the Dragon, which focal length will give me the same Field Of View in Super 35 ?

Lens on Dragon * Crop Factor = Lens in Super 35 with same FOV

$27 \text{ mm} * 0.78 = \mathbf{21 \text{ mm}}$

SENSOR DIMENSIONS & CROP FACTORS

For calculating Super 35 Equivalent Lenses with same Field of View

EXAMPLE

“I’m shooting 1.85 and I have a 27mm on the Dragon in 6K mode
 What lens would give me the same field of view in Super 35?”
 Dragon Super 35 crop factor for 1.85 in 3rd table below = 0.82.
 $27\text{mm} \times 0.82 = 22.1\text{mm}$.

	4 PERF Super 35	Sony F55 Full Aperture	Arri Alex Open Gate	Red Dragon 6K mode
MAXIMUM SIZES				
aspect ratio	1.33	1.89	1.55	1.94
H	24.92	24.00	28.17	30.70
V	18.67	12.70	18.13	15.80
diagonal	31.14	27.15	33.50	34.53
ASPECT RATIO = 2.39				
H	24.00	24.00	28.17	30.70
V	10.04	10.04	11.79	12.85
diagonal	26.02	26.02	30.54	33.28
Super 35 crop factor =		1.00	0.85	0.78
ASPECT RATIO = 1.85				
H	24.00	23.60	28.17	29.23
V	12.97	12.70	15.23	15.80
diagonal	27.28	26.71	32.02	33.23
Super 35 crop factor =		1.02	0.85	0.82
ASPECT RATIO = 1.78				
H	24.00	23.60	28.17	28.12
V	13.48	12.70	15.83	15.80
diagonal	27.53	25.93	32.31	32.26
Super 35 crop factor =		1.06	0.85	0.85

Bold numbers are used with aspect ratio to calculate the other numbers in the same column
 dimensions are in millimeters

Note that the **Crop Factors** in the table above are based on using the **maximum area** of the sensors, and they can vary a little on the same camera because we're starting with either full aperture **width** or the full aperture **height**.

Some filmmakers prefer to use a safe area with a little cushion around the frame; they may use, for example, 95% or 93% of the Dragon's full aperture. In these cases the crop factors must be recalculated with the smaller dimensions.

RULES OF THUMB to get the same FOV with different sensors

1. **Bigger sensors require longer lenses** to get the same FOV as Super 35.

You will need a longer lens on a Dragon to get the same shot as on a F55.

2. The Sony **F55 is very close to Super 35**

So the FOV will be close to what filmmakers are used to with Super 35.

3. To get the same FOV on the Dragon as with Super 35, you need to go to the **next focal length up** on the Dragon.

So a 21mm in Super 35 will frame roughly the same shot as a 27mm on a Dragon.

QUICK FOV REFERENCES

For crews who want to shoot with a large sensor camera, it could be useful to offer a **Quick Field of View Reference** showing the focal lengths in Super 35 with the same Field Of View, right in the camera case.

As an example, here are 2 "cheat sheets" for using Primo 70 focal lengths with the 2.39 format. There is no real need for a cheat sheet for the Sony F55 as it is the same as Super 35 in 2.39.

The idea is to do these for every format and every sensor -- a simple reference that could be in the camera case or ditty bag.

QUICK FIELD OF VIEW REFERENCE

Arri Alexa => Super 35

Focal lengths with same Field of View

	ARRI ALEXA	SUPER 35
	OPEN GATE	4 PERF
	18	15
Primo 70	24	20
Primes	27	23
	35	30
	40	34
	50	43
	65	55
	80	68
	100	85
	125	106
	150	128
	200	170
	250	213
Primo 70	70-185	60-157
Zooms	200-400	170-340

aspect ratio = 2.39

crop factor = 0.85

Example

65mm on the Arri Alexa

has same Field Of View

as 55mm on Super 35

QUICK FIELD OF VIEW REFERENCE

Dragon 6K => Super 35

Focal lengths with same Field of View

	RED DRAGON	SUPER 35
	6K	4 PERF
	18	14
Primo 70	24	19
Primes	27	21
	35	27
	40	31
	50	39
	65	51
	80	62
	100	78
	125	98
	150	117
	200	156
	250	195
Primo 70	70-185	55-144
Zooms	200-400	156-312

aspect ratio = 2.39

crop factor = 0.78

Example

65mm on the Dragon

has same Field Of View

as 51mm on Super 35

THE WIDE ANGLE ISSUE

As mentioned in the first white paper, the Primo 70s are designed for a 70mm sensor, which has a Crop Factor of about 2. So the **widest lens** in the Primo 70 series, the 24mm, has roughly the same Field Of View as a 12mm in Super 35, which is plenty wide. However when using the Primo 70s with **smaller sensors**, the 24mm may not be wide enough.

When shooting 2.39, the 24mm has the same Field Of View as:

- 19mm on a Dragon 6K,
- 20mm on an Alexa Open Gate.

(The Field Of View on the Sony F55 is 24mm, the same as Super 35).

This may not be a wide enough angle for many filmmakers, who will expect to see lenses with Fields Of View roughly equivalent to that of a 14mm in Super 35.

Filmmakers are used to having these **wider focal lengths** in their package, and they're especially useful in interiors, when the camera is up against a wall.

If we apply the crop factors this implies that we are missing wide lenses with focal lengths around **18 millimeters**.

This is why the shortest focal length is **grayed out** in the Quick Reference Guides. As of now, there are no Primo 70s below 24mm. Panavision is working on manufacturing some as soon as possible.

In the meantime, Panavision technicians are assisting filmmakers in selecting and adapting existing lenses to cover the wide end. The difficulty is to find lenses that can intercut with the Primo 70s. This wide-angle lens selection is an **ongoing process**.

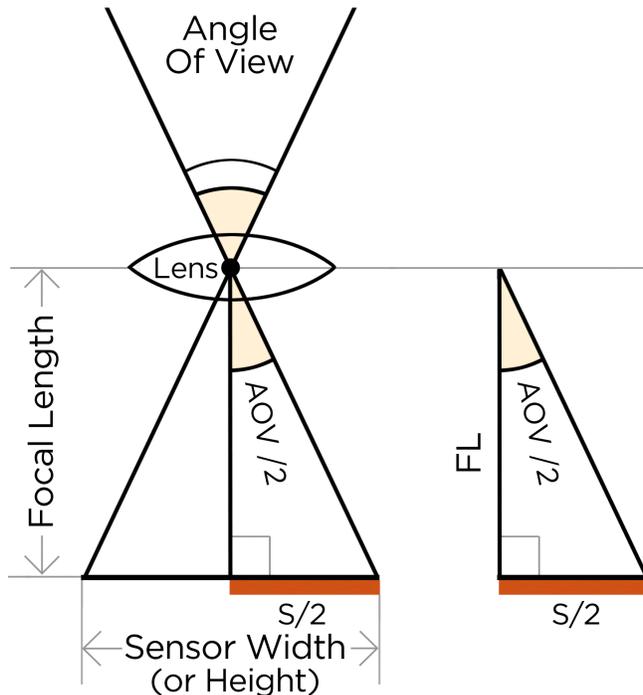
SENSOR SIZE & DEPTH OF FIELD

Sensor size has no effect on the depth of field. A 21mm at T2.8 will always be a 21mm at T2.8, whether it's on a 70mm camera, a Red Dragon, or a Super 35 camera. However a 27 mm on a Red Dragon will give you the same Field of View as a 21 mm on Super 35, and using a longer lens gives you less depth of field.

So at the **same camera position** and with the **same framing**, a filmmaker will get less **depth of field** on a Red Dragon than on Super35, but only because he has to use a longer lens.

APPENDIX. HOW TO CALCULATE ANGLE OF VIEW

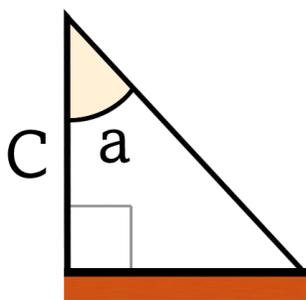
The Calculation of the Angle of View (be it Horizontal, Vertical or Diagonal) involves applying a little trigonometry to our previous diagram of the sensor, lens & focal length.



We obtain a right-angle triangle with half the sensor dimension ($S/2$) on one side, and the focal length (FL) on the other.

The top angle of this triangle is equal to half the Angle of View ($AOV/2$).

Now for the trigonometry: the ARCTAN function.



$$\text{Arctan} (B/C) = a$$

$$\text{angle } a = \text{ARCTAN} (B / C)$$

$$AOV/2 = \text{ARCTAN} (S/2 \text{ divided by } FL)$$

$$AOV/2 = \text{ARCTAN} (S / 2FL)$$

$$AOV = 2 \text{ ARCTAN} (S / 2FL)$$

$$\text{Angle of View} = 2 \times \text{ARCTAN} (\text{Sensor Dimension} / (2 \times \text{Focal Length}))$$

For those using Excel, the formula is below (sensor dimension in millimeters):
 $\text{AngleOfView} = \text{DEGREES} (2 * \text{ATAN} (\text{SensorDimension} / (2 * \text{FocalLength})))$

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