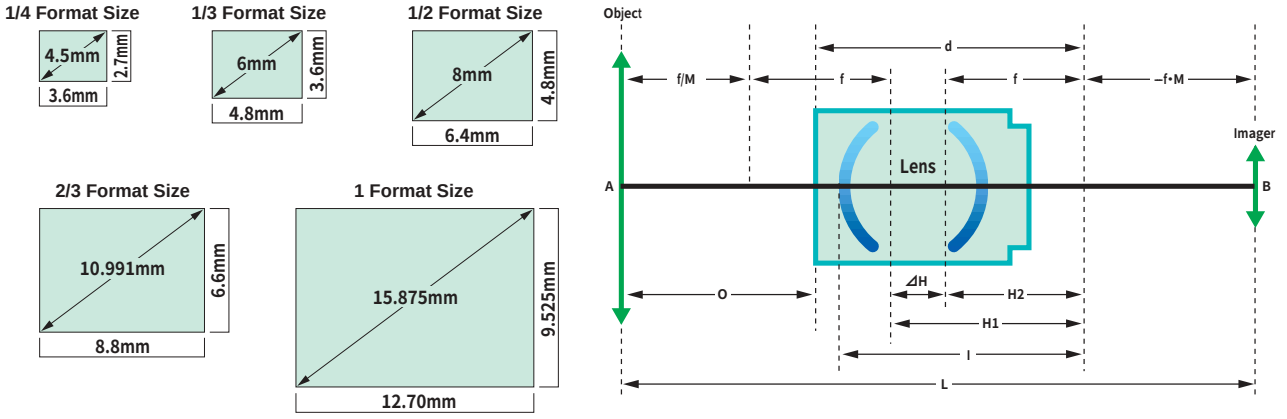
Optical Calculation for Close-Up Monitoring



1. Obtain a rough idea of the focal length required for your application with the object distance and the magnification between the object size and image size by using the following formula :

   f=O×M

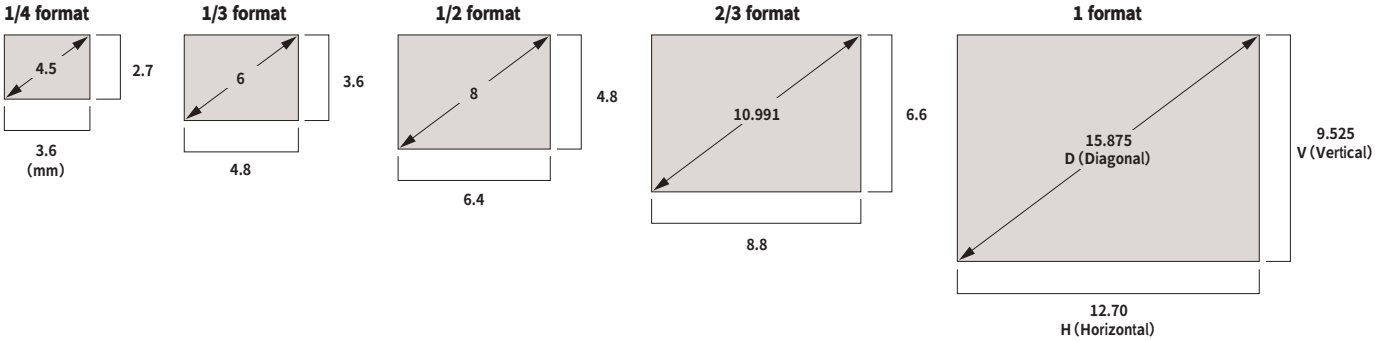
2. Then, select one of the closest PENTAX lenses to the above figure, and then calculate the overall distance, L, by adding up figures indicated in the attached table.

   L=f / M+f+f+⊿H+f×M

3. Finally, you can get an exact object distance, O, or the length of the extension tube, fxM, by the following substractions :

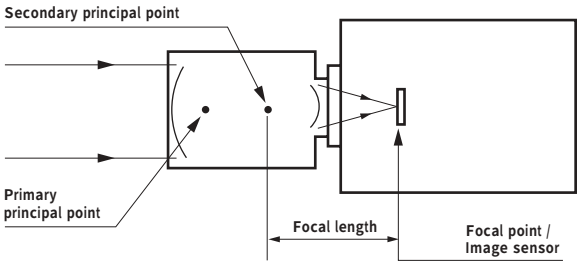
   O=L−d−f×M or f×M=L−O−d

A	Object Size (Vertical or Horizontal)
B	Imager Format Size (Vertical or Horizontal)
M	Magnification (B/A)
f	Focal Length
⊿H	Interval of Principal Positions
H1	1st Principal Position
H2	2nd Principal Position
d	Distance between the front end of lens barrel and the focal point
I	Distance between the 1st lens element and the focal point
f • M	Length of the extension tube or the spacer to be placed between the camera and the lens
O	Object Distance (Distance between the front end of lens barrel and the object)



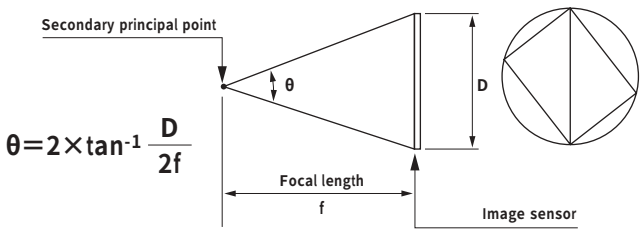
Focal Length

Rays from infinitely distance objects are condensed internally in the lens at a common point on the optical axis. The point at which the image sensor of the CCTV camera is positioned, is called a focal point. By virtue of design, lenses have 2 principal points, a primary principal point & a secondary principal point, the distance between the secondary principal point and the focal point (image sensor) determines the focal length of the lens.



Angle of View

The angle formed by the 2 lines from the secondary principal point to the image sensor is called the angle of view. Therefore, the focal length of the lens is fixed regardless of the image format size of the CCTV camera. Conversely, the angle of view varies in accordance with the image size. The focal lengths in the catalog are nominal and the angles of view calculated by the formula referring to the focal lengths are approximate.



$$\theta = 2 \times \tan^{-1} \frac{D}{2f}$$

F-Number

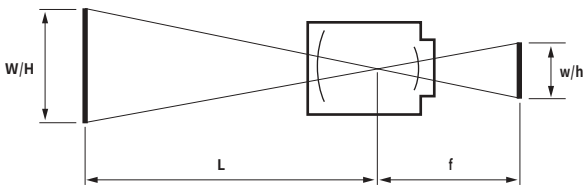
The F number is the index for the amount of light that passes through a lens. The smaller the number, the greater the amount of light. The F number is a ratio between focal length and effective aperture as follows.

$$\text{F Number} = \frac{f}{D}$$

f = focal length
D = effective diameter

Field of View

The field of view varies along with the focal length of the lens as follows.



$$\frac{w}{W} = \frac{h}{H} = \frac{f}{L}$$

W : width of object
H : height of object
w : width of format
1/2 format = 6.4mm, 1/3 format = 4.8mm,
1/4 format = 3.6mm
h : height of format
1/2 format = 4.8mm, 1/3 format = 3.6mm,
1/4 format = 2.7mm
f : focal length
L : object distance

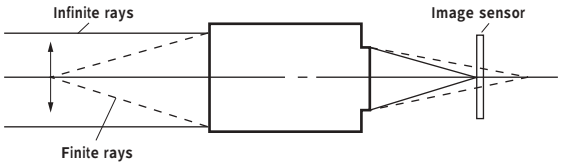
Example : Full image of 4.5m-high object on a TV monitor camera: 1/3 format, Object distance: 10m
H = 4.5m = 4,500mm L = 10m = 10,000mm

$$\frac{h}{H} = \frac{f}{L} \longrightarrow \frac{3.6}{4{,}500} = \frac{f}{10{,}000} \longrightarrow f = 8\text{mm}$$

Close-Up Application

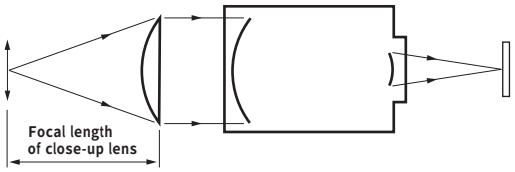
1) Extension Tube (Macro Ring)

When the rays originate from a finite object distance, the rays are condensed at a point further than the focal point, while the rays from infinite distance are condensed at the actual focal point. The focus adjustment moves the lens barrel toward the object to shift the focusing point at the image sensor. However, the amount of focusing adjustment is mechanically limited as sees by the minimum object distance. Extension Tube (Macro Ring) is inserted in between the lens and camera to shift the focus point further than the mechanical limit for close-up focus.



2) Close-Up Lens

The close-up lens has a positive meniscus lens as a supplementary lens. Generally, 3 types of close-up lenses are available, close-up lens No.1, 2 & 3 have 1,000mm (1,000mm/1), 500mm (1,000mm/2), 333mm (1,000mm/3) respectively. When an object is placed at the focal point of the close-up lens, the rays from the object are converted by the close-up lens to be parallel rays against the optical axis as seen on the right.



This lens is effective when wishing to come closer to an object than the min. object distance of a lens, or taking close-up pictures of small objects.

Depth of Field

When an object is focused, it is typically observed than the area in front and behind the object is also in focus. The range in focus is called depth of field. When the background is extended to infinity, the object distance (focusing distance) is called hyper focal distance. Depth of field is calculated by using the following formula.

$$H = \frac{f^2}{C \times F}$$

$$T1 = \frac{B(H+f)}{H + B}$$

$$T2 = \frac{B(H-f)}{H - B}$$

F = F No.
H = hyper focal distance
f = focal length
B = object distance (measured from image sensor)
T1 = near limit
T2 = far limit
C = circle of least confusion
1/2 format = 0.015mm, 1/3 format = 0.011mm,
1/4 format = 0.008mm

Depth of field increases when:
∗Focal length is shorter
∗F-number is larger (F/1.4 < F/5.6)
∗Object distance is longer

CS and C mount

CS mount as present CCTV market standard is specially designed for CCTV camera lens developed by PENTAX. This is to minuturize the size and to improve the performance of lens by shortening the flange back by 5mm comparing to C mount.C and CS mount lenses are available in the present market, and CS mount is only applicable to CS mount camera.C mount lens is applicable not only to C mount camera but also to CS mount camera by using 5mm Adapter Ring (as C-CS-A).