大话成像之

数字成像系统 32讲

光学基础

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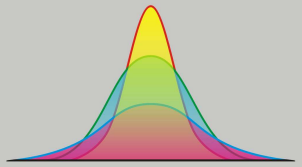
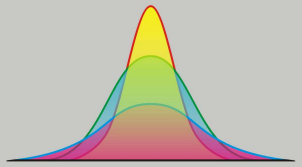


非光学工程师为什么要了解光学知识：

- 成像工业是从镜头开始的，小孔成像是人类发现光学的开始。
- 相机有不同类型的镜头：定焦，变焦，不同的光学指标。
- 自动对焦算法工程师要理解几何光学部分。
- 图像信号处理工程师对光学缺陷的理解。
- 图像质量工程师对光学有关特性的分析。
- Camera相关工程师必须了解基本光学概念，用准确的术语沟通。
- 这部分培训主要是介绍针对自动对焦应用相关的光学概念



光学部分的重要概念：

reflection：

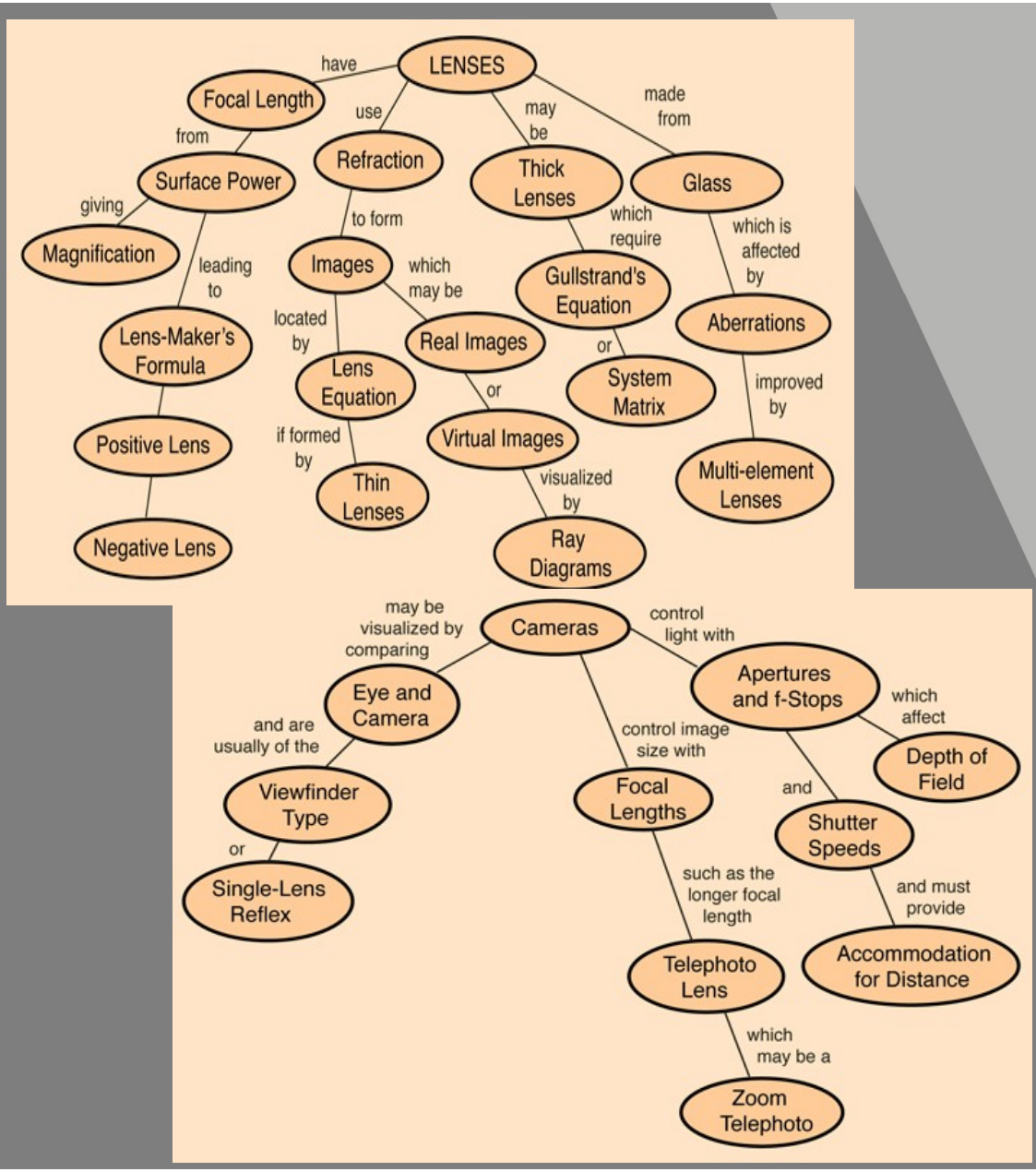
refraction：

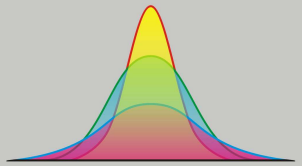
Aperture,

F-number, focal length

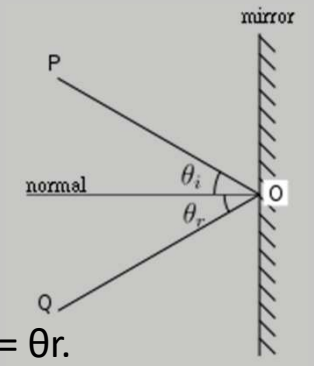
CoC, Depth of field

Tele , macro , Zoom ……





反射reflection：



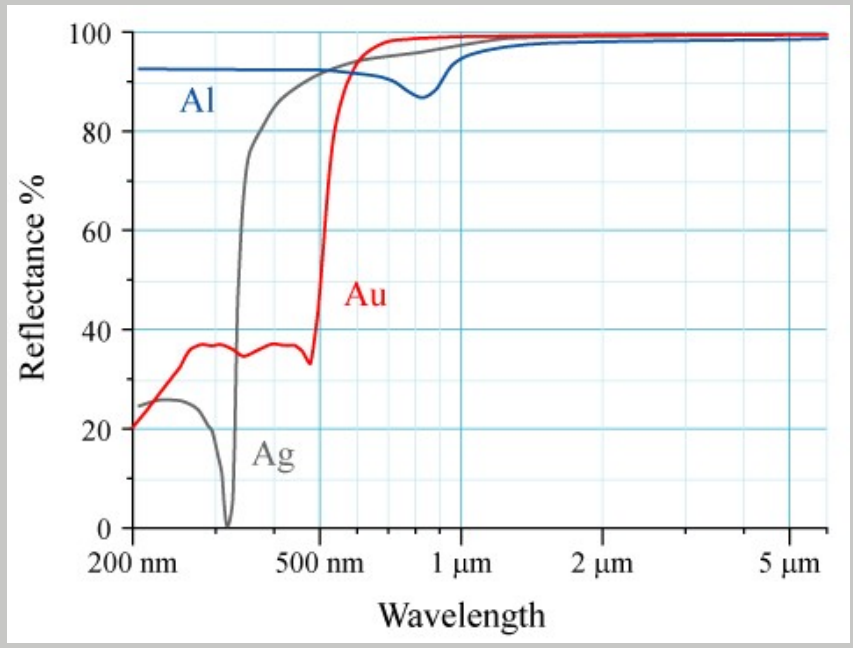
θi = θr.

反射角（θr）等於入射角（θi）

与入射光的波长无关

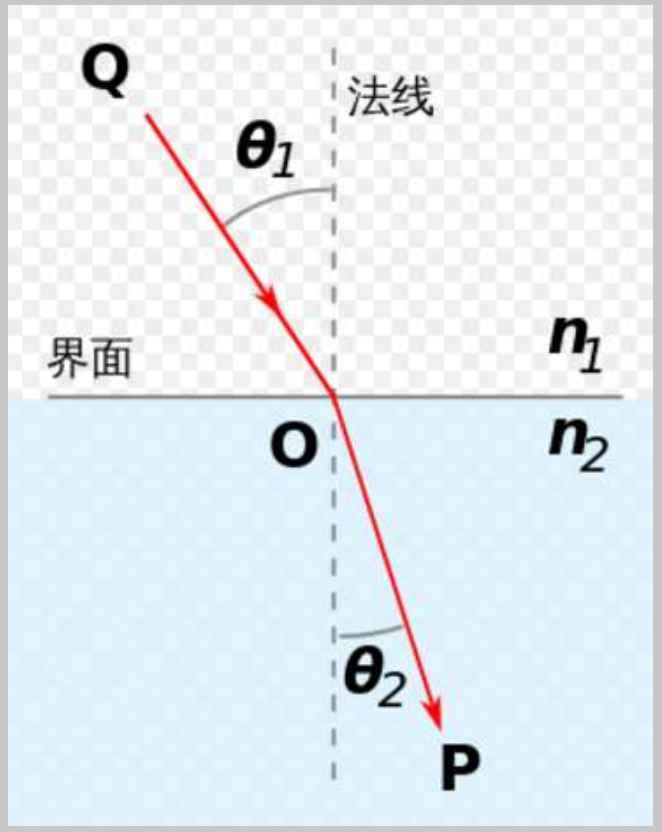
入射光 反射光 法线处于同一平面

反射率：入射光功率与反射光功率之比（非几何光学概念）



https://zh.wikipedia.org/wiki/反射

折射refraction：



https://en.wikipedia.org/wiki/Snell%27s_law

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

$$n = \frac{c}{v}$$

n：折射率
λ：波长（传播介质中的）
V：速度（传播介质中的）
C：光速

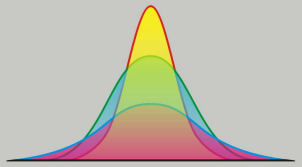
折射率n就是把光线偏折的能力
n越大，光线速度衰减越多，折射角度越大

n也受到湿度，压力，温度，波长的一定影响

$$\lambda_{glass} = \frac{n_{air}}{n_{glass}} \cdot \lambda_{air} \approx \frac{\lambda_{air}}{n_{glass}}$$

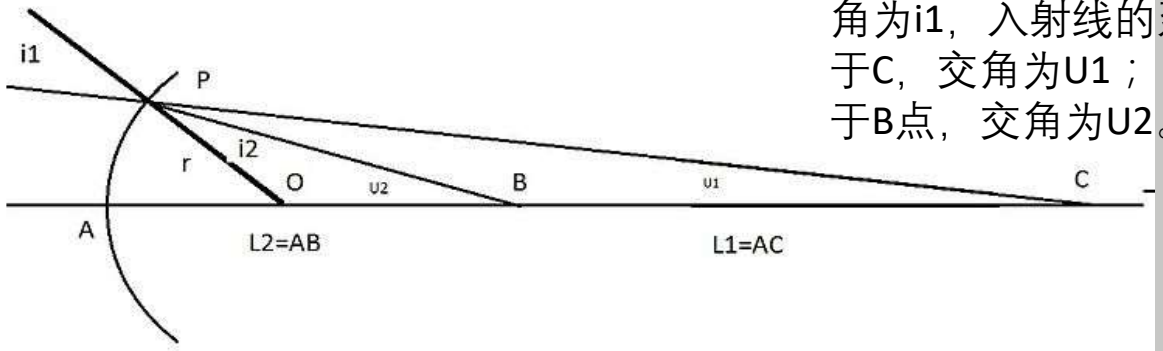
光从空气到玻璃的折射，波长会被压缩

常用折射率：
真空 1.0000
空气 1.0003
水 1.33
玻璃 1.5 - 1.8

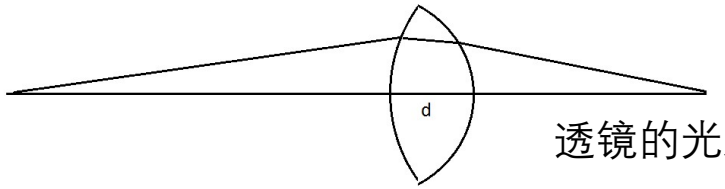


球面折射sphere refraction：

图中PA 是一个球面，球心为O，半径为r。光轴为AOBC 入射光线在P点与球面相交，入射线与球面的垂直线交角为i1，入射线的延长线与光轴相交于C，交角为U1；折射线与光轴相交于B点，交角为U2。

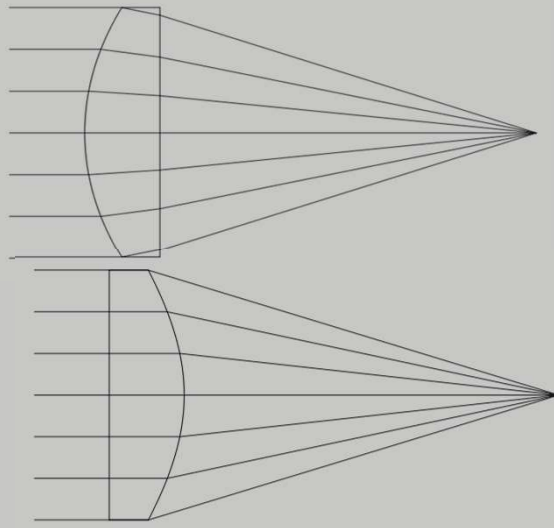


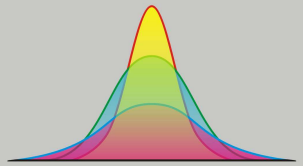
Refraction of a spherical surface



透镜的光路计算

最简聚焦系统





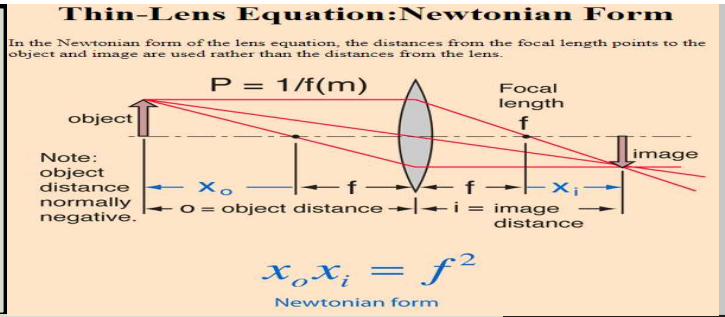
https://zh.wikipedia.org/wiki/球面折射

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

$$xx' = f^2$$

$$m = -\frac{s'}{s}$$

$$m = -\frac{f}{x} = -\frac{x'}{f}$$

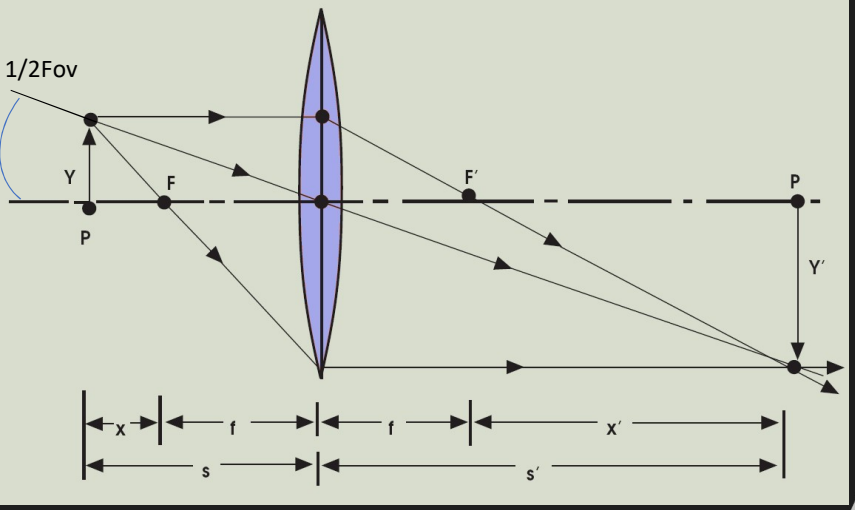


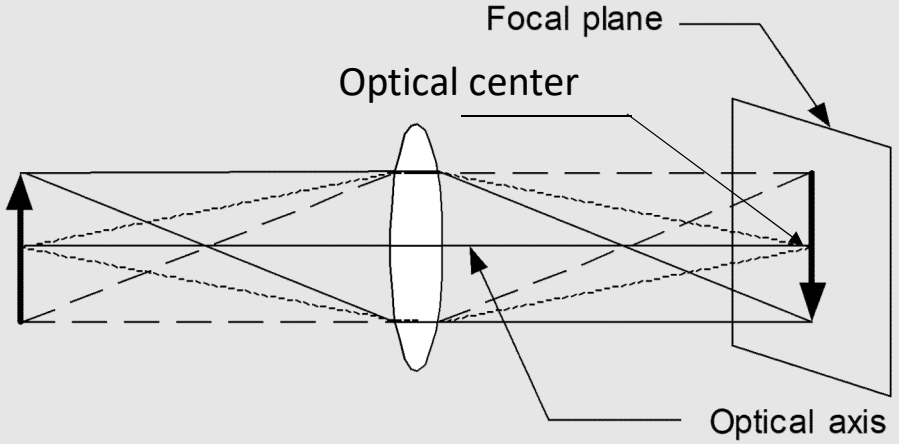
Focal plane：对焦平面

Optical axis: 光轴

Optical center: 光心

Focal length (f): 焦距





s:物距

s‘: 像距

x : 物距减焦距 （s ≈ x）

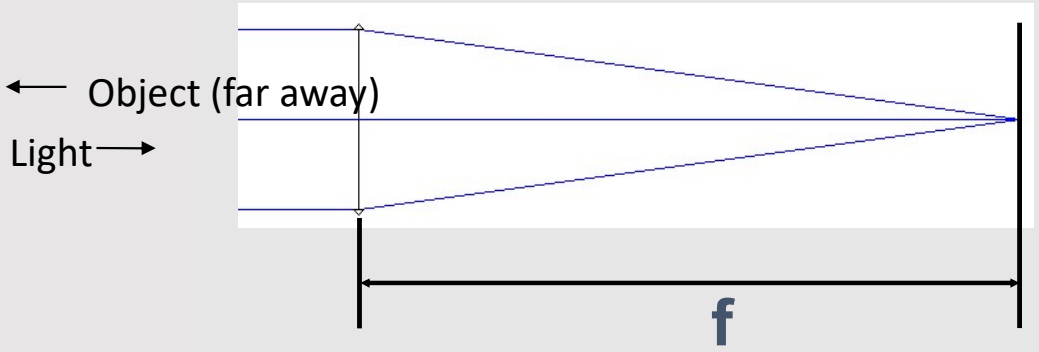
x‘: 像距减焦距

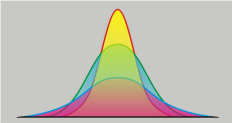
F : 焦距

m: 线性放大率

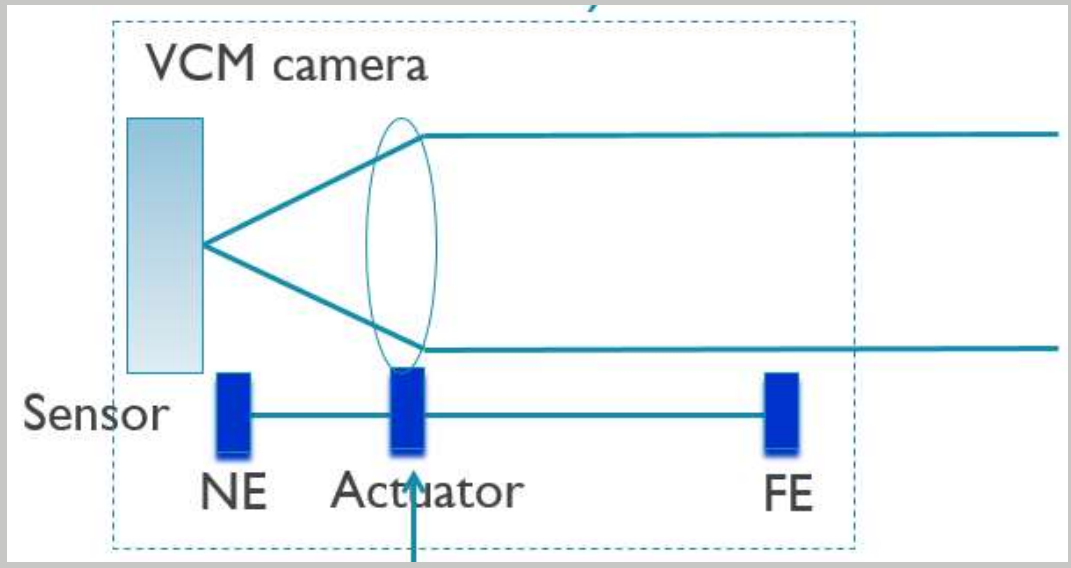
Y: 物高

Y‘ : 像高





牛顿公式在自动对焦中的一个应用：
计算对焦马达（actuator）的冲程范围



已知：

f （焦距）：**4 mm**

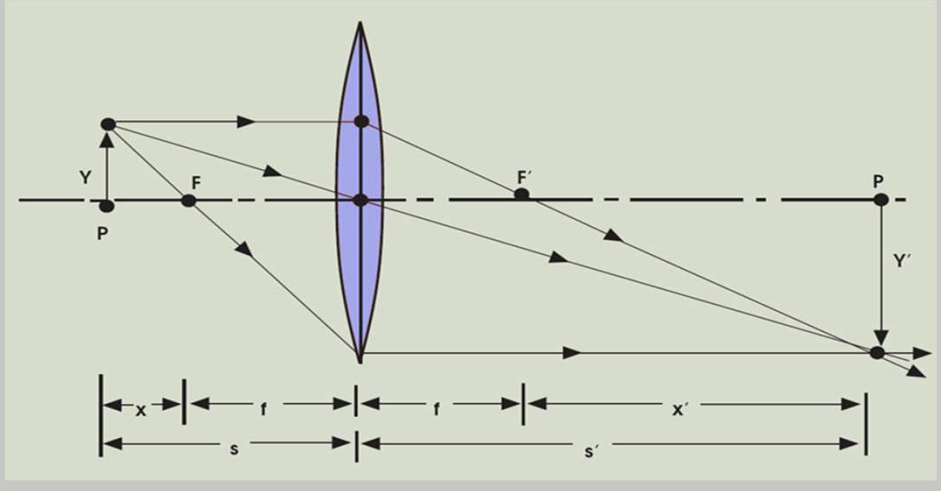
X （物距）：Infinity to ~ **10 cm**

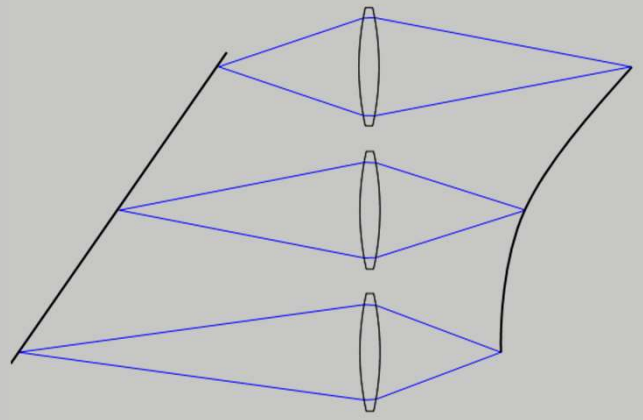
求：

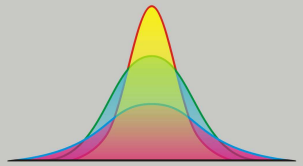
x’ （对焦点移动范围） = 马达冲程

x’ = 0，当物距在Infinity时

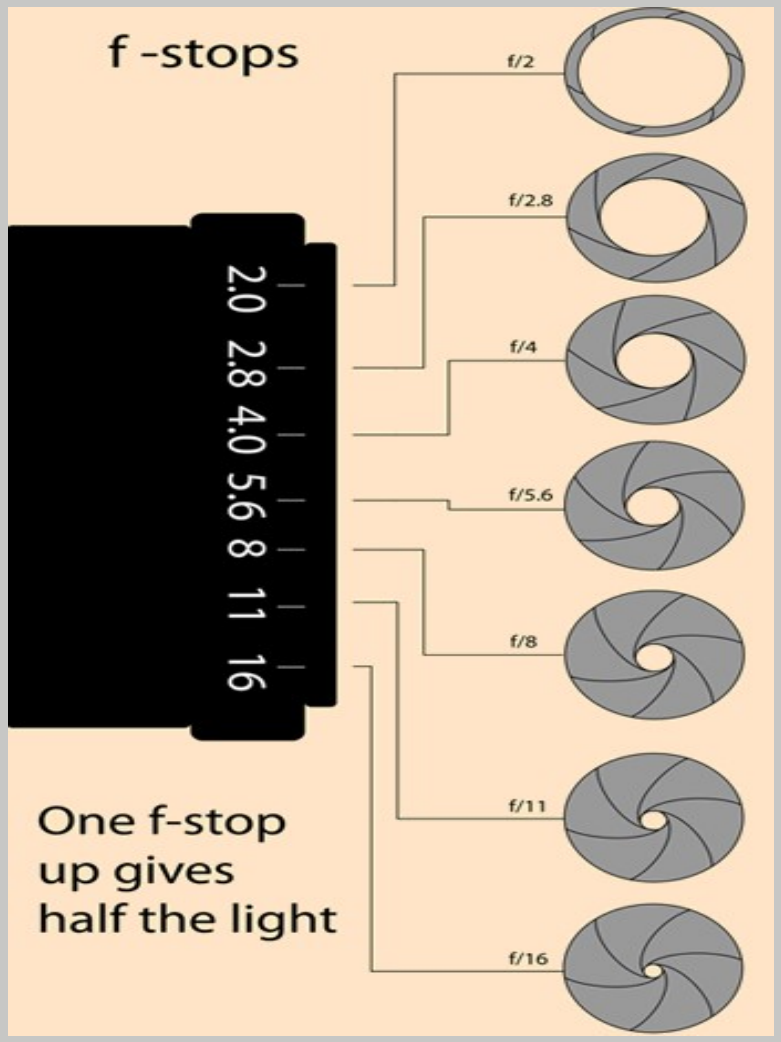
x’ = f^2 / x = (4 mm)^2 / (100 mm) = **0.16 mm**





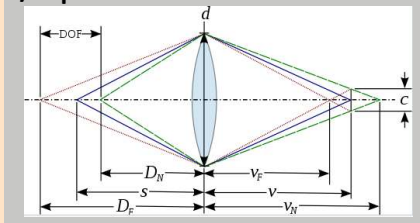


aperture光圈 depth of field 景深



N= $\frac{f}{D} = \frac{\text{focal length}}{\text{Diameter of aperture}}$

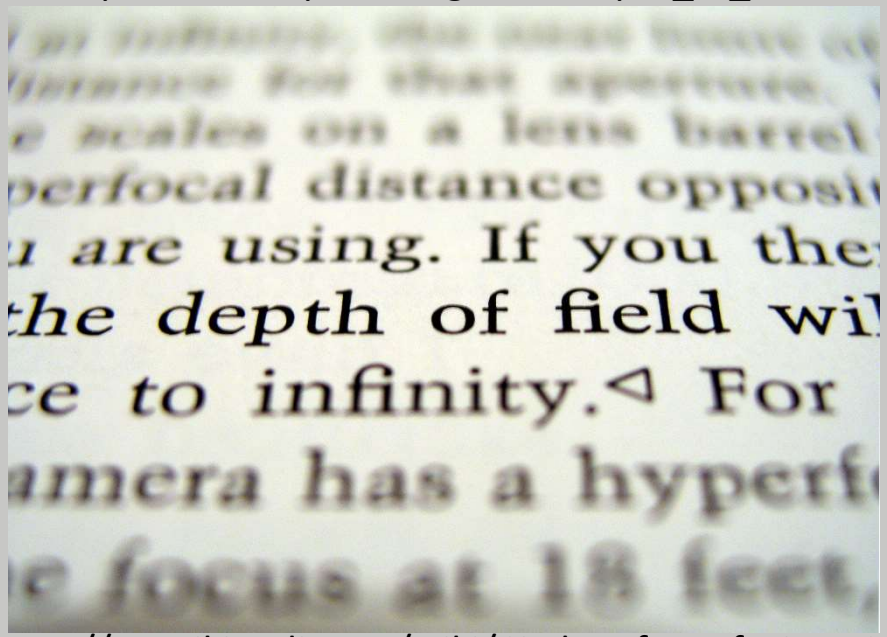
https://en.wikipedia.org/wiki/Aperture



$$\text{DOF} \approx \frac{2Ncf^2s^2}{f^4 - N^2c^2s^2}$$

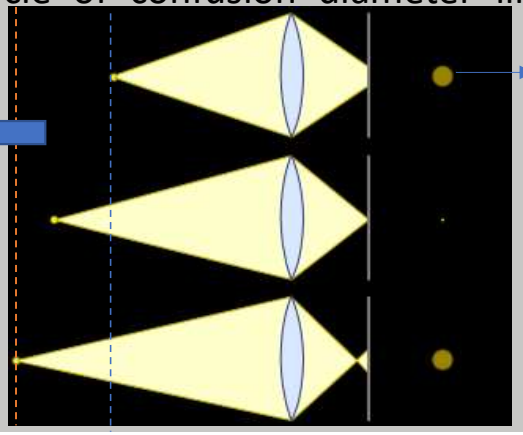
https://zh.wikibooks.org/wiki/Maple/准确的景深公式

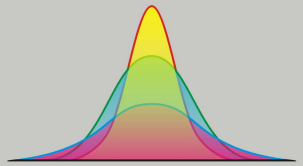
https://en.wikipedia.org/wiki/Depth_of_field



https://en.wikipedia.org/wiki/Circle_of_confusion#Circle_of_confusion_diameter_limit_in_photography

DOF in CoC=c

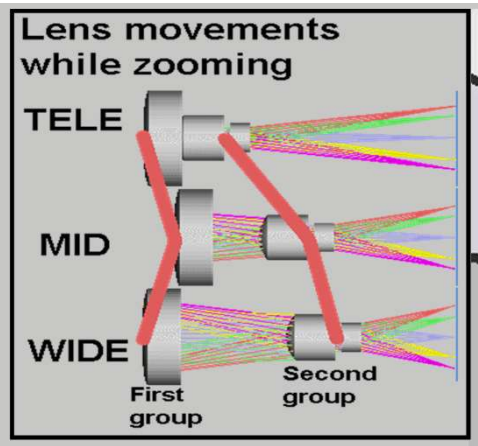


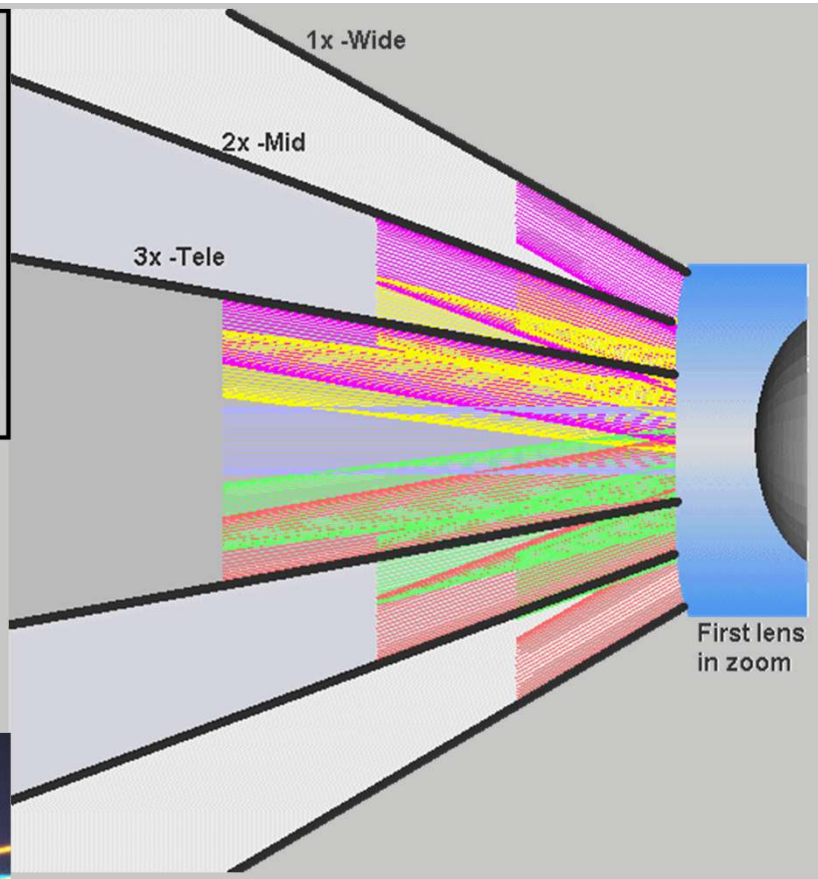


https://en.wikipedia.org/wiki/Depth_of_field#DOF_formulae

zoom

Optical zoom = Change the lens focal length
Digital zoom = Crop and upscale



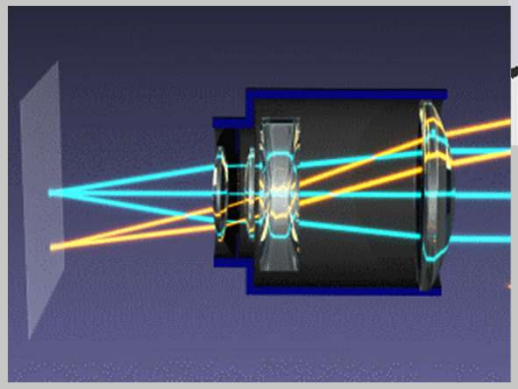


Zoom factor

= Longest focal length / shortest focal length

= Wide FOV / Tele FOV

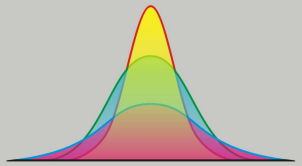
FOV = Field of View



A simple zoom has two moving lens groups
Zooming:
- Mostly second group (also longest travel range)
- Partially first group

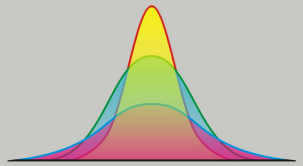
Focusing:
- Either first group or both groups together

https://en.wikipedia.org/wiki/Zoom_lens



THANKS

本课程由 Maver Jiang提供



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