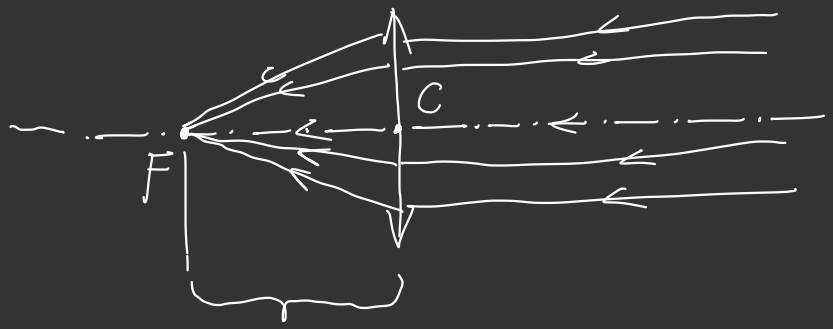
光心 optical center

主轴 principal axis

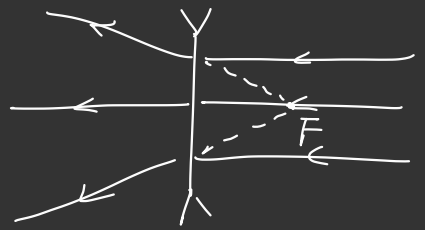
焦点 focal point

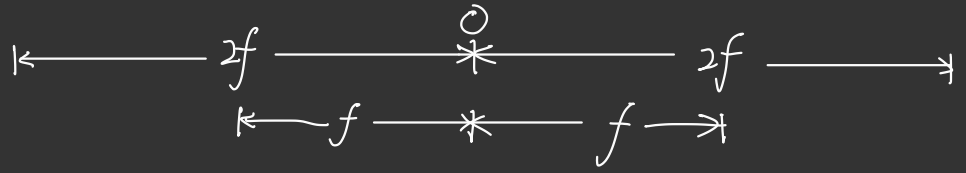
focal length 焦距



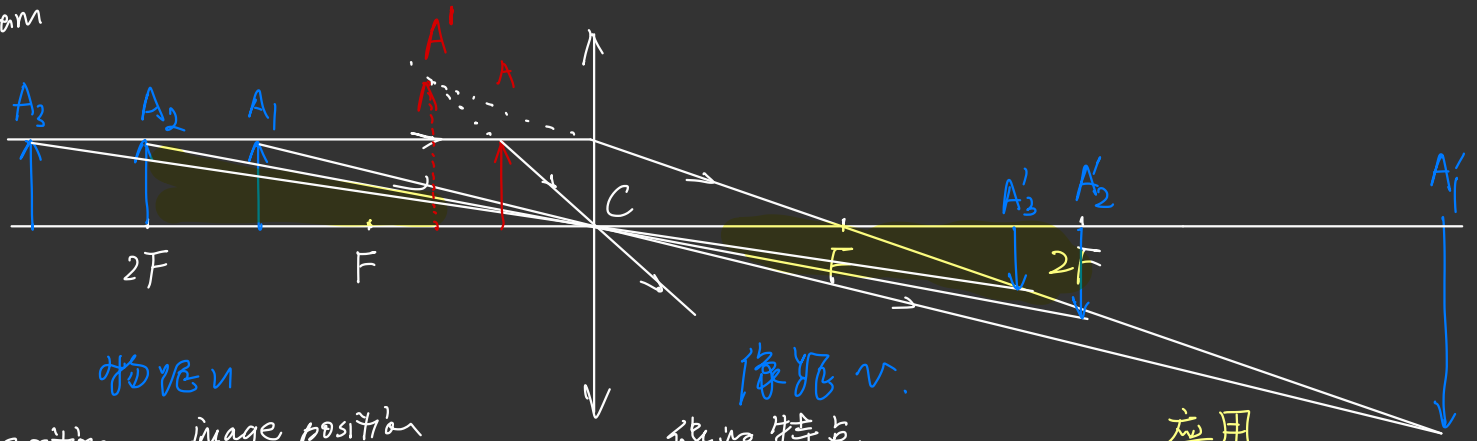

凸透镜—会聚 converging lenses

凹透镜—发散 diverging lenses



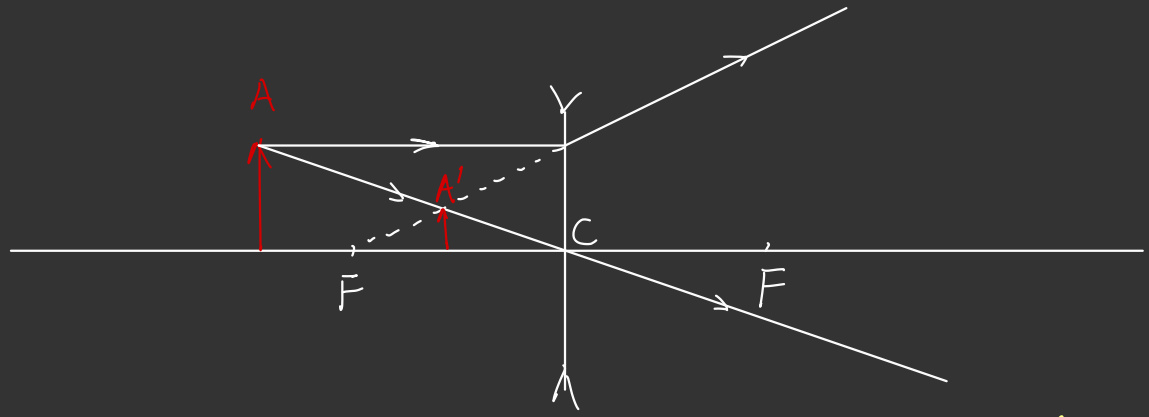



光路图
ray diagram



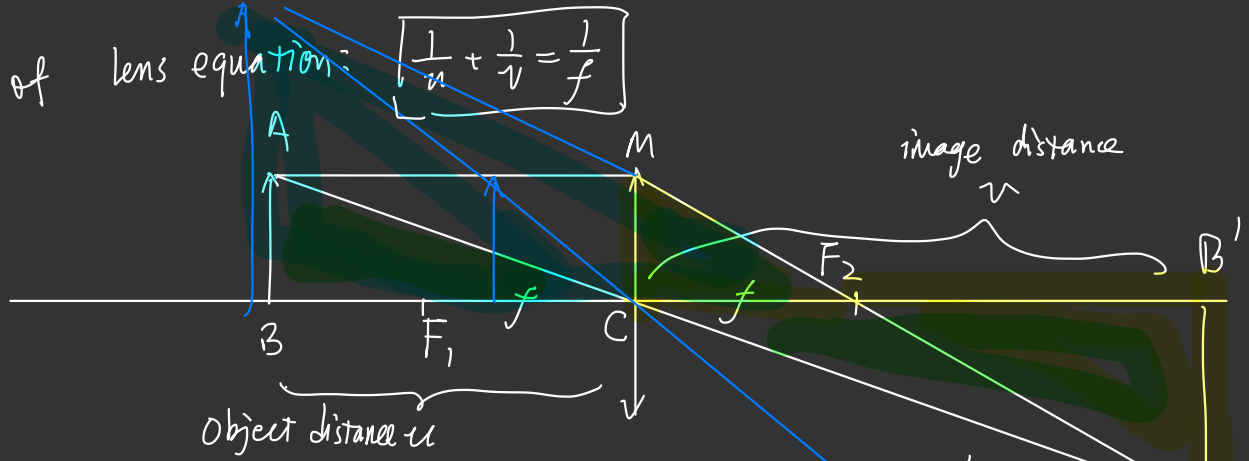

物距 u　　像距 v.

| | Object position | image position | 像的特点 | | | 应用 |
|---|---|---|---|---|---|---|
| 1 | $u > 2f$ | $f < v < 2f$ | 倒立 inverted | 缩小 smaller | 实像 real image | 照相机，眼睛 |
| 2 | $u = 2f$ | $v = 2f$ | 倒立 | 等大 of same size | 实像 | 测焦距 |
| 3 | $f < u < 2f$ | $v > 2f$ | 倒立 | 放大 larger | 实像 | 幻灯机，投影仪原理<br>测焦距 |
| 4 | $u = f$ | 不成像 | | | | |
| 5 | $u < f$ | $v > u$ | 正立 upright | 放大 larger | 虚像 virtual | 放大镜，老花镜 |




凹： $u > v$ 正立 缩小 虚像 近视镜

# Proof of lens equation: $\boxed{\frac{1}{u}+\frac{1}{v}=\frac{1}{f}}$




**Proof:**

① $\triangle ABC \backsim \triangle A'B'C$

$$\frac{BC}{AB}=\frac{B'C}{A'B'}$$

$$\frac{u}{AB}=\frac{v}{A'B'} \quad (1)$$

$$\frac{u}{v}=\frac{AB}{A'B'}$$

② $\triangle F_2MC \backsim \triangle F_2A'B'$

$MC=AB$

$$\frac{MC}{CF_2}=\frac{A'B'}{F_2B'}$$

$$\frac{AB}{f}=\frac{A'B'}{v-f} \quad (2)$$

$$\frac{AB}{A'B'}=\frac{f}{v-f}$$

$$\frac{u}{v}=\frac{f}{v-f} \Rightarrow u(v-f)=vf \Rightarrow uv-uf=vf$$

$uv = uf + vf$

$uv = (u+v)f$

$$\frac{1}{f} = \frac{u+v}{uv} = \frac{u}{uv} + \frac{v}{uv} = \frac{1}{v} + \frac{1}{u} \quad \square$$

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

Object: image:

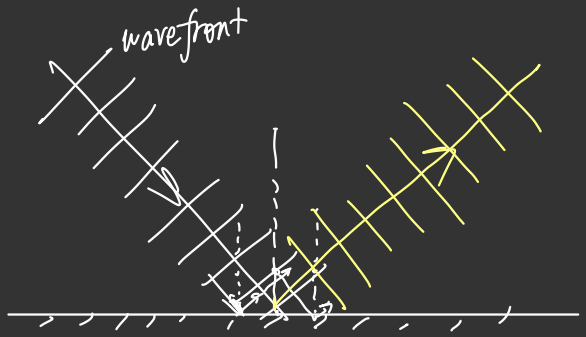
$u = 2f$, $v = 2f$, $\frac{1}{2f} + \frac{1}{2f} = \frac{1}{f}$ ✓ $\frac{1}{2} + \frac{1}{2} = 1$

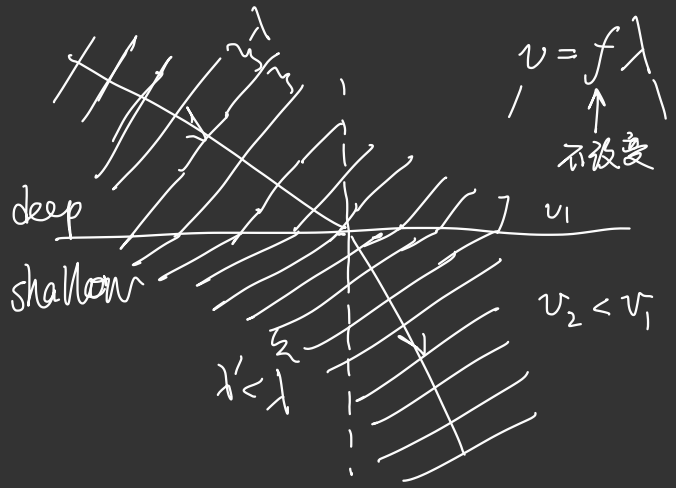
$u > 2f$

$\frac{1}{3f} + \frac{1}{f} = 1$

$\frac{1}{\frac{4}{3}f} + \frac{1}{?} = 1$ $f < \frac{4}{3}f$ $v > 2f$

$\frac{4}{5} + \frac{1}{?} = 1$


wavefront


$v = f\lambda$
不改变
deep
shallow
$v_1$
$v_2 < v_1$
$\lambda' < \lambda$