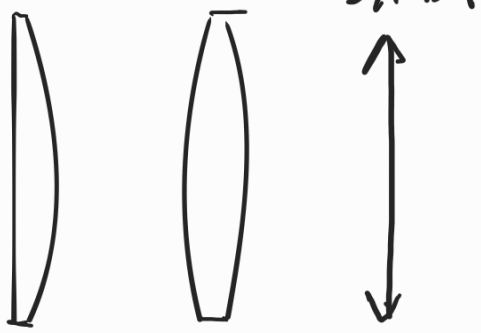
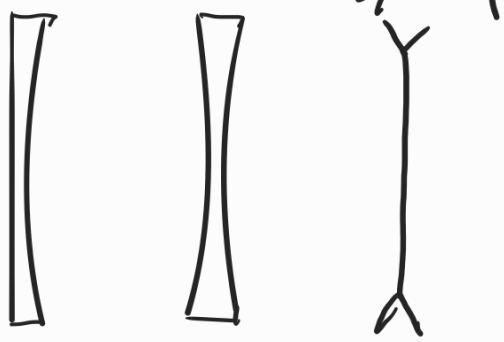
3.7 LENSES 透鏡



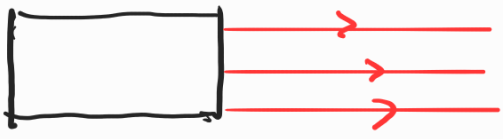
convex lens
凸透鏡



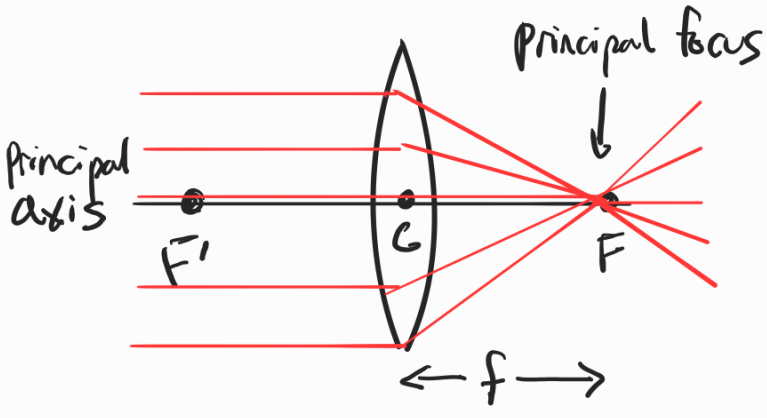
concave lens
凹透鏡

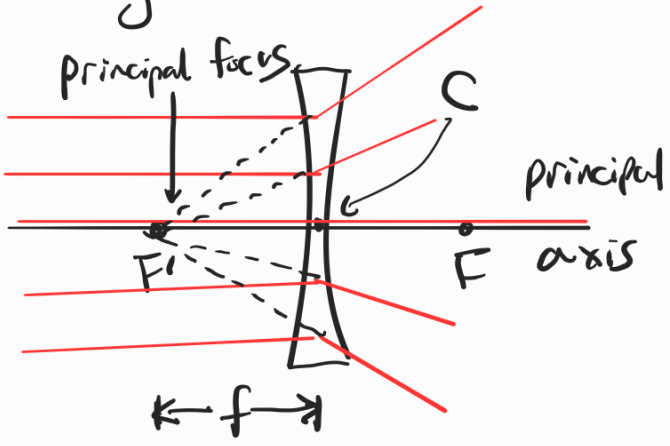
柱面 ① cylindrical lens → curve in one direction

球面 ② spherical lens → curve in all direction



cylindrical lens are useful for ray box tracing.





C : optical centre

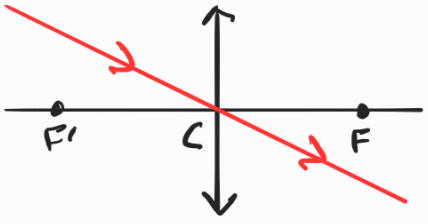
Principal axis passes through C perpindicularly

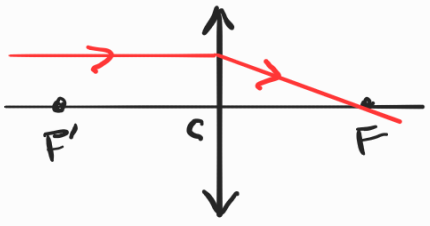
Principal focus : F or F'

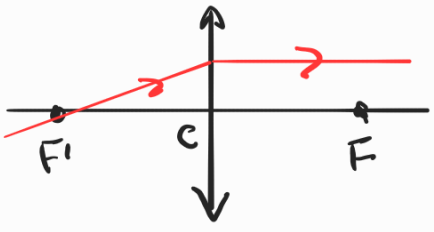
f : focal length

Rules for Ray Tracing

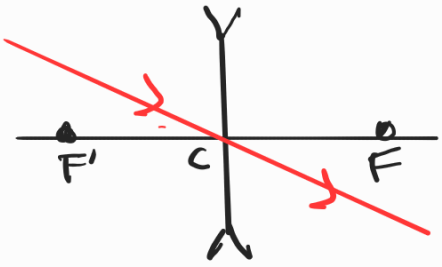
CONVEX

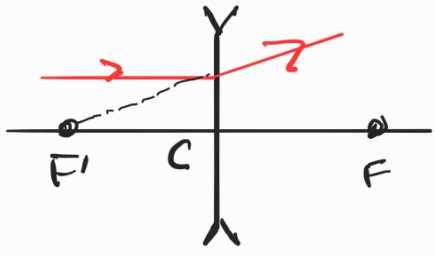


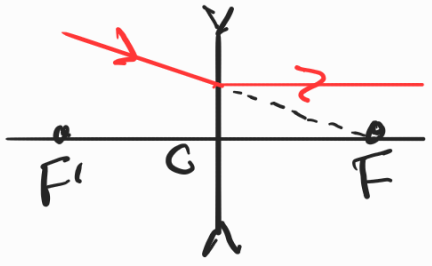




CONCAVE







Rule 1

A ray passes straight through C

Rule 2

A parallel ray focus (convex) or diverge (concave) on the principal focus

Rule 3

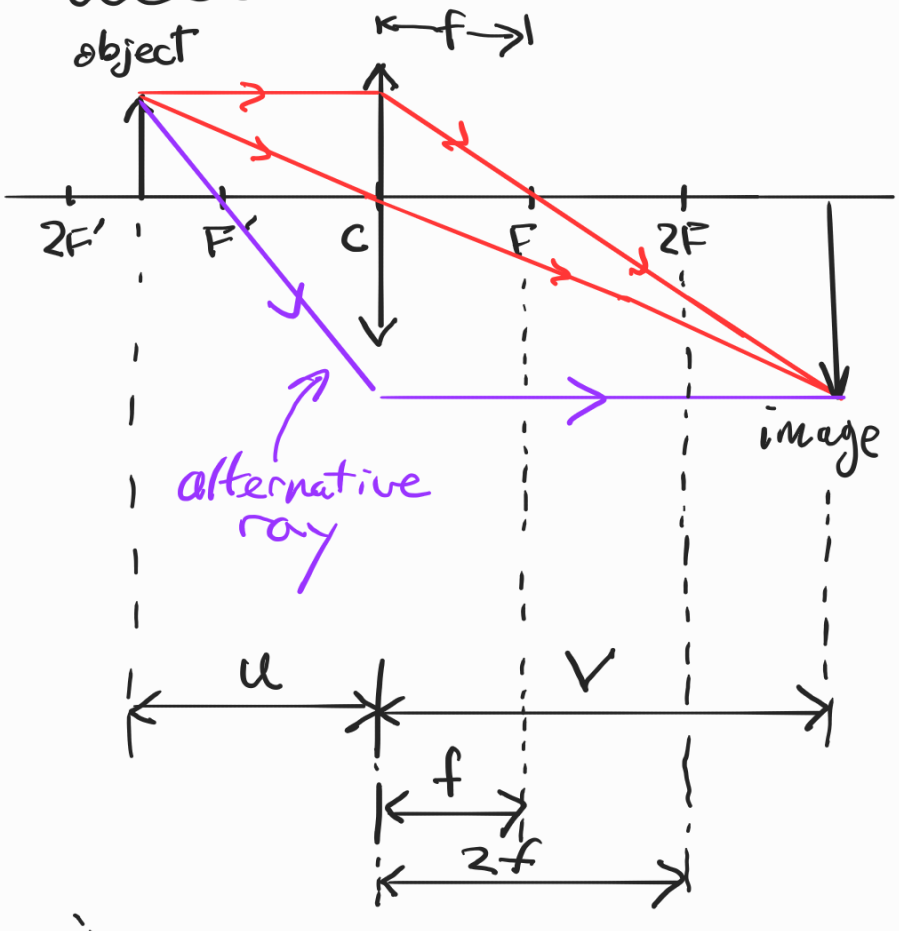
An incident ray directed to (concave) or travelling from (convex) becomes parallel to principal axis

Image Construction

Draw, in the following order

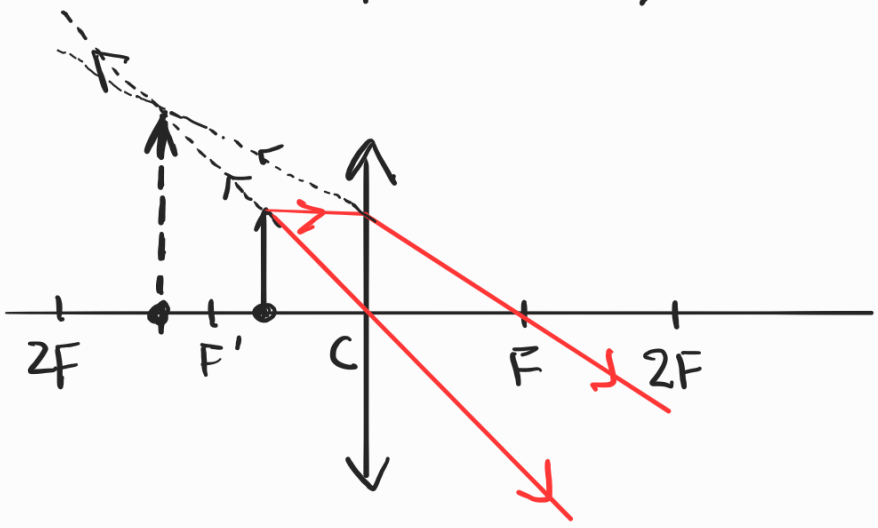
1. The scale and the principal axis
2. The lens and 2x focus points
3. The object
4. Any 2 rays, from the object
5. If refracted ray converge, draw solid line, real image (實像)
   If diverge, draw dotted line, and virtual image (虛像)

CONVEX LENS



In this case:

* $f < u < 2f$
* $v > 2f$
* inverted
* real (實像)
* magnified

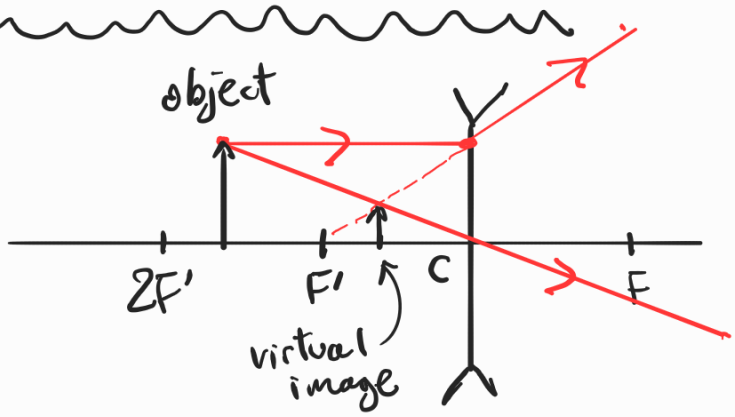


In this case:

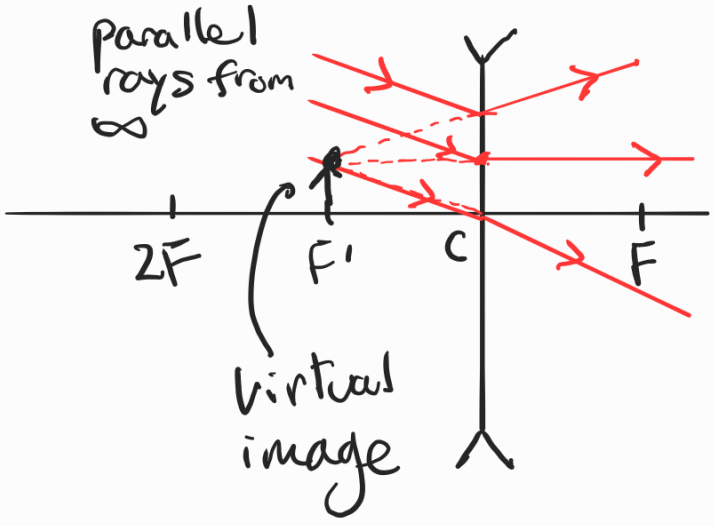
* $u < f$
* $v > u$
* erect
* virtual (虛像)
* magnified

	ⓤ	ⓥ			
	∞	$v = f$	inverted	real	diminish 縮細
	$u > 2f$	$f < v < 2f$			
	$u = 2f$	$v = 2f$			same
⇒	$f > u > 2f$	$v > 2f$			magnified
	$u = f$	∞	—	—	—
⇒	$u < f$	$v > u$	erect	virtual	magnified

CONCAVE LENS



* $f < u < 2f$
* $V < f$
* erect
* virtual
* diminished



* u very far away
* $v = f$
* erect
* virtual
* diminished

(u)	(v)	image	image	size
all	$v \leq f$	erect	virtual	diminished

magnification of images : $m = \frac{v}{u}$

$m > 1$ magnified

$m < 1$ diminished

Lens formula

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

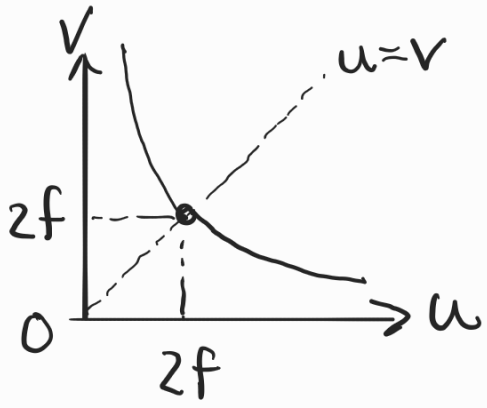
u : always positive

v : real positive; virtual negative

f : convex positive; concave negative

Lens formula and graphs

V and U

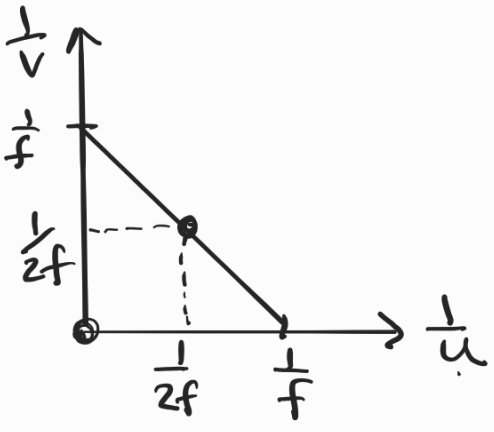


For Convex lens

* $u = v$, when they are both at 2f

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

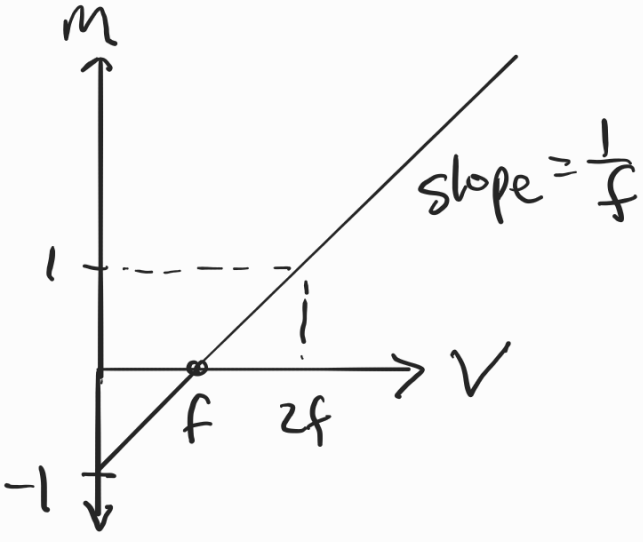
$\frac{1}{V}$ and $\frac{1}{u}$



for any lens

* slope $= -1$
* x intercept $= \frac{1}{f}$; y intercept $= \frac{1}{f}$
* $u \to \infty$, then $\frac{1}{v} \to 0$

m and v



For any lens

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

m

$$m = \left[\frac{1}{f}\right] v - 1$$

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