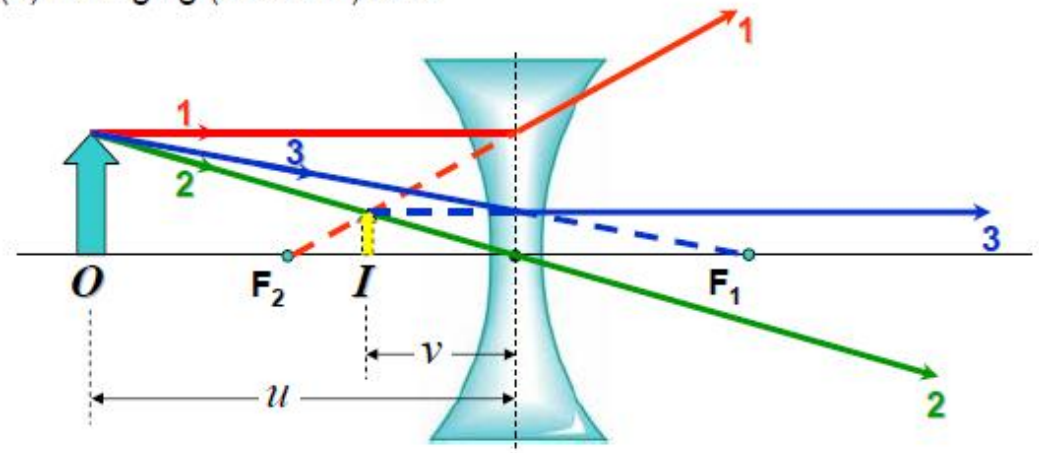
(b) Diverging (concave) lens

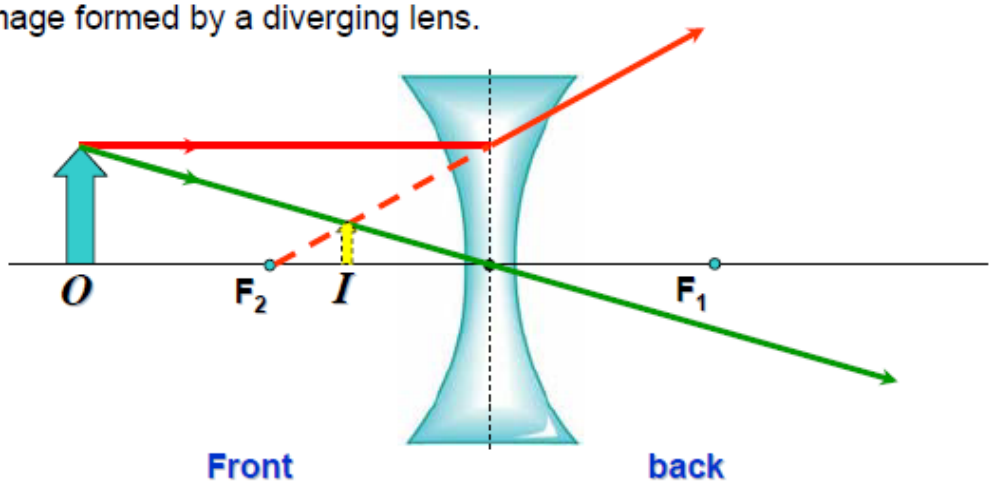


At least any two rays for drawing the ray diagram.

- **Ray 1** - Parallel to the principal axis, after refraction by the lens, passes through the focal point (focus) F_2 of a converging lens or appears to come from the focal point F_2 of a diverging lens.
- **Ray 2** - Passes through the optical centre of the lens is undeviated.
- **Ray 3** - Passes through the focus F_1 of a converging lens or appears to converge towards the focus F_1 of a diverging lens, after refraction by the lens the ray parallel to the principal axis.

1.5.Images Formed by a diverging Lens

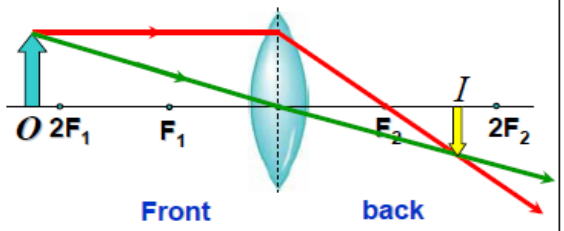
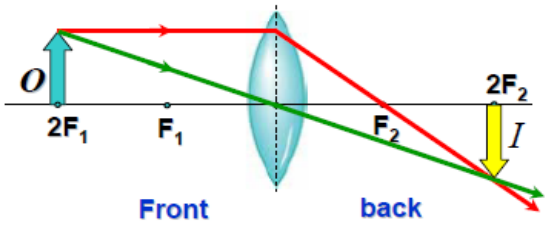
- Ray diagrams below showing the graphical method of locating an image formed by a diverging lens.

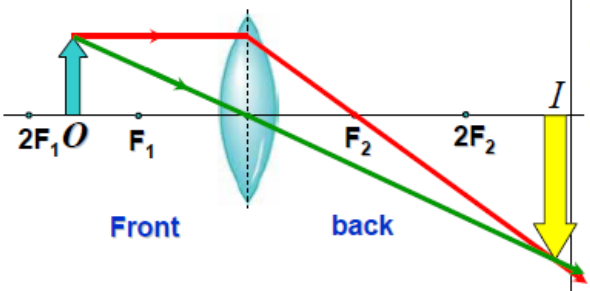
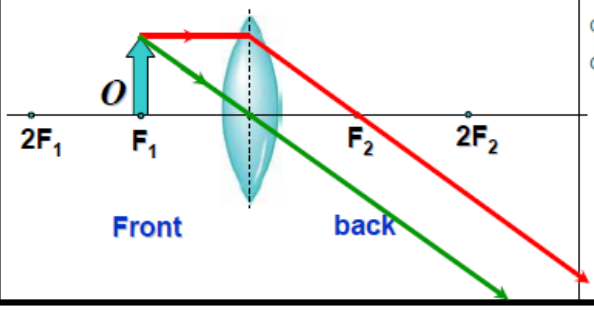


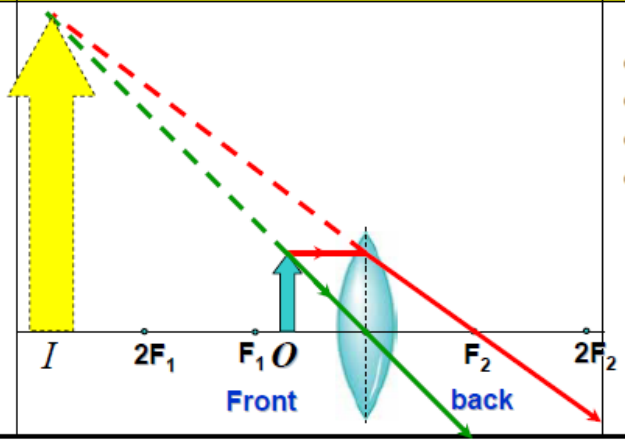
- Properties of image formed are
  - virtual
  - upright
  - diminished (smaller than the object)
  - formed in front of the lens.
- Object position → any position in front of the diverging lens.

1.6.Images Formed by a converging Lens

- Table below shows the ray diagrams of locating an image formed by a converging lens for various object distance, u.

Object distance, u	Ray diagram	Image property
$u > 2f$		○ Real ○ Inverted ○ Diminished ○ Formed between point F_2 and $2F_2$. (at the back of the lens)
$u = 2f$		○ Real ○ Inverted ○ Same size ○ Formed at point $2F_2$. (at the back of the lens)

Object distance, u	Ray diagram	Image property
$f < u < 2f$		○ Real ○ Inverted ○ Magnified ○ Formed at a distance greater than $2f$ at the back of the lens.
$u = f$		○ Real ○ Formed at infinity.

Object distance, u	Ray diagram	Image property
$u < f$		○ Virtual ○ Upright ○ Magnified ○ Formed in front of the lens.

○ Linear (lateral) magnification of the thin lenses, M is defined as *the ratio between image height, h_i and object height, h_o*

Simulation

$$M = \frac{h_i}{h_o} = -\frac{v}{u}$$

where

v : image distance from optical centre

u : object distance from optical centre

Negative sign indicates that when u and v are both positive, the image is inverted and h_o and h_i have opposite signs.

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1.7.Thin Lens Formula And Lens Maker's Equation

○ Considering the ray diagram of refraction for 2 spherical surfaces as shown in figure below.