Light — formula sheet Class 10 Science · reflection and refraction

Key formulas: mirrors, lenses, refraction

MIRROR FORMULA

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

u, v, f all measured from the pole.

MAGNIFICATION (MIRROR)

$$m = h' \div h = -v \div u$$

h' = image height, h = object height.

FOCAL LENGTH AND RADIUS

$$f = R \div 2$$

R = radius of curvature. Centre of curvature C is at 2f.

LENS FORMULA

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

Distances from the optical centre O. Note the minus sign.

MAGNIFICATION (LENS)

$$m = h' \div h = v \div u$$

No minus sign here, unlike the mirror.

POWER OF A LENS

$$P = 1 \div f$$

f in metres, P in dioptre (D). Convex: P is +. Concave: P is –.

REFRACTIVE INDEX

$$n = c \div v$$

c = speed of light in vacuum (3×10^8 m/s), v = speed in the medium.

RELATIVE INDEX

$$n_{21} = v_1 \div v_2 = n_2 \div n_1$$

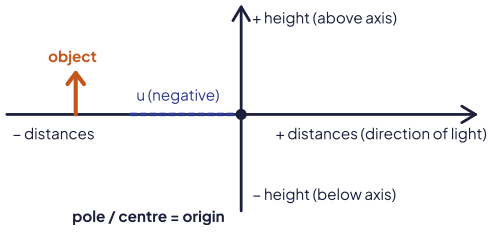
Medium 2 with respect to medium 1.

SNELL'S LAW

$$\sin i \div \sin r = \text{constant}$$

The constant is n_{21} for the two media. i and r are measured from the normal.

New Cartesian sign convention



Quantity	Sign rule
Object	Placed to the left of the mirror or lens. Light travels left → right.
Distances along the axis	Measured from the pole or centre. Same way as the light = **+**, against it = **–**.
Heights	Above the principal axis = **+**, below = **–**.
Real object	u is always **–**. Object height h is **+**.

	Focal length f	Real image	Virtual image
Concave mirror	negative	v negative (in front), h' negative (inverted)	v positive (behind), h' positive (erect)
Convex mirror	positive	Image always virtual, erect, smaller: v positive, m between 0 and +1	
Convex lens	positive	v positive (other side), h' negative	v negative (same side as object), h' positive
Concave lens	negative	Image always virtual, erect, smaller: v negative, m between 0 and +1	

Where does the image form?

Concave mirror — object at …

Object	Image at · size	Nature
Infinity	F · tiny, point-like	Real, inverted
Beyond C	F to C · smaller	Real, inverted
At C	At C · same size	Real, inverted
Between C and F	Beyond C · larger	Real, inverted
At F	Infinity · much larger	Real, inverted
Between F and P	Behind it · larger	Virtual, erect

Convex lens — object at …

Object	Image at · size	Nature
Infinity	F_2 · tiny, point-like	Real, inverted
Beyond $2F_1$	F_2 to $2F_2$ · smaller	Real, inverted
At $2F_1$	At $2F_2$ · same size	Real, inverted
Between F_1 and $2F_1$	Beyond $2F_2$ · larger	Real, inverted
At F_1	Infinity · much larger	Real, inverted
Between F_1 and O	Object's side · larger	Virtual, erect

Worked examples

An object is 30 cm in front of a concave mirror of focal length 15 cm. Find v and m.

u = –30 cm, f = –15 cm

1/v = 1/f – 1/u = –1/15 + 1/30 = –1/30, so **v = –30 cm**

m = –v/u = –(–30)/(–30) = **–1**. Real, inverted, same size, formed at C.

An object is 20 cm from a convex lens of focal length 10 cm. Find v, m and the power.

u = –20 cm, f = +10 cm

1/v = 1/f + 1/u = 1/10 – 1/20 = 1/20, so **v = +20 cm**

m = v/u = 20/(–20) = **–1**. P = 1/0.10 m = **+10 D**. Real, inverted, same size.

Quick check: light travels at 2×10^8 m/s in glass, so $n = 3 \times 10^8 \div 2 \times 10^8 = 1.5$. **Slips to avoid:** mirror m formula used for a lens · f in cm for power · positive f for a concave mirror.