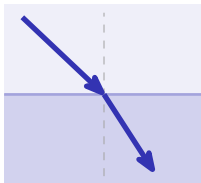


# Geometric Optics

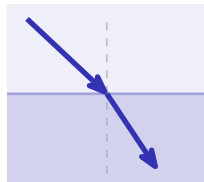
AP Physics 2 ■ Unit 13

AP Physics 2



# What we will cover

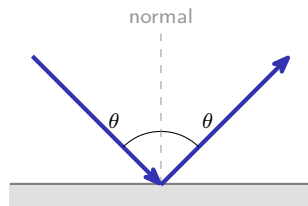
- 1 Reflection
- 2 Images formed by mirrors
- 3 Refraction and Snell's law
- 4 Images formed by lenses



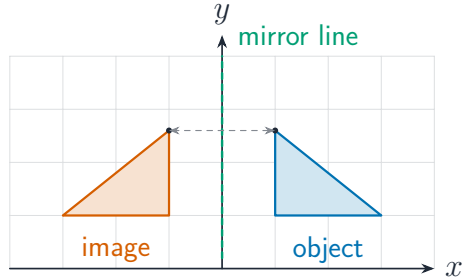
# Reflection

Model light as a **ray** 光线. The **law of reflection** 反射定律: the angle of incidence equals the angle of reflection (from the **normal**).

- **specular** 镜面反射 – smooth surface, a clear image
- **diffuse** 漫反射 – rough surface, scattered rays



# Reflection



# Images formed by mirrors

## Mirror equation

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}, \quad m = -\frac{s_i}{s_o}$$

- **real** 实像 ( $s_i > 0$ ): can be projected on a screen
- **virtual** 虚像 ( $s_i < 0$ ): only appears behind the mirror
- $m < 0$  inverted;  $|m| > 1$  enlarged

## Worked example

Object 30 cm, concave  $f = 10$  cm:

$$\frac{1}{30} + \frac{1}{s_i} = \frac{1}{10} \Rightarrow s_i = 15 \text{ cm}$$

$$m = -\frac{15}{30} = -0.5$$

Real, inverted, half size.

# Refraction and Snell's law

Crossing into a new medium, light changes speed and bends:

## Snell's law

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

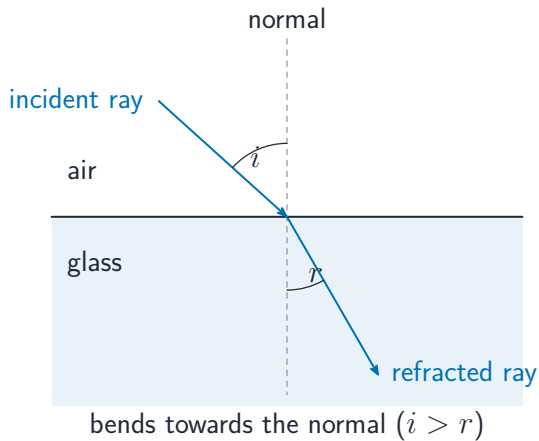
**index 折射率**  $n = c/v$ ; higher  $n$  bends light more.

Past the **critical angle 临界角** ( $\sin \theta_c = n_2/n_1$ ): **total internal reflection 全内反射** – fibre optics.



*Refraction bends light at boundaries*

# Refraction and Snell's law



# Images formed by lenses

A **converging lens** 会聚透镜 (convex) bends parallel rays to a focus; a **diverging lens** 发散透镜 spreads them.

## Thin-lens equation

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

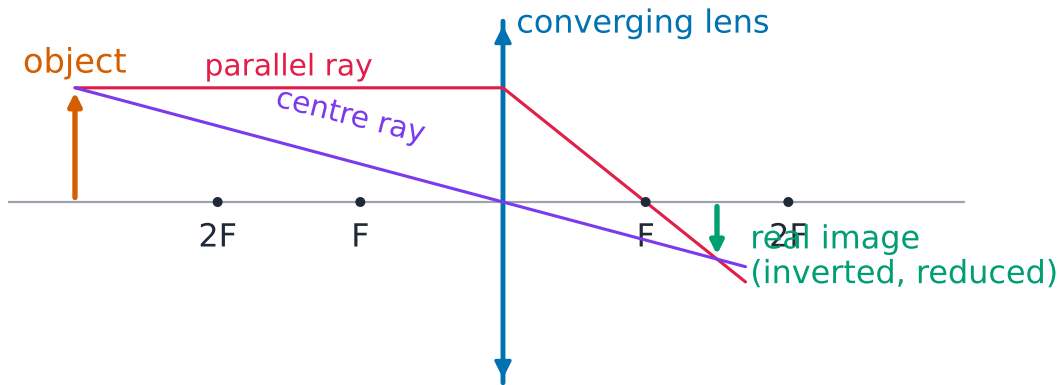
Same form as the mirror equation; a camera and the eye cast a real image.



*Lenses form real and virtual images*



# Images formed by lenses



## Unit 13 – key takeaways

### 1 Reflection

angle in = angle out from the normal

### 2 Mirrors

$$1/s_o + 1/s_i = 1/f, m = -s_i/s_o$$

### 3 Refraction

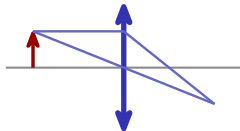
$n_1 \sin \theta_1 = n_2 \sin \theta_2$ ; TIR past the critical angle

### 4 Lenses

same thin-lens equation; converging casts a real image

## Check yourself

- 1 A ray hits a mirror at  $25^\circ$  to the normal – at what angle does it leave?
- 2 A negative magnification means the image is...?
- 3 Light enters a denser medium – does it bend toward or away from the normal?
- 4 What effect makes fibre-optic cables work?



**Answers** 1.  $25^\circ$  2. inverted 3. toward the normal 4. total internal reflection