KERALA TEACHER ELIGIBILITY TEST (K-TET) • CATEGORY III • SYLLABUS 2012

UNIT 2 : LIGHT

Physical Science • Part A : Physics • Complete Study Note

Inside this note
- ✓ Concept map & mind map
- ✓ Ray diagrams & figures
- ✓ Differentiation tables
- ✓ Memory tips & mnemonics
- ✓ Daily-life examples
- ✓ Formulas & worked examples
- ✓ Practice questions

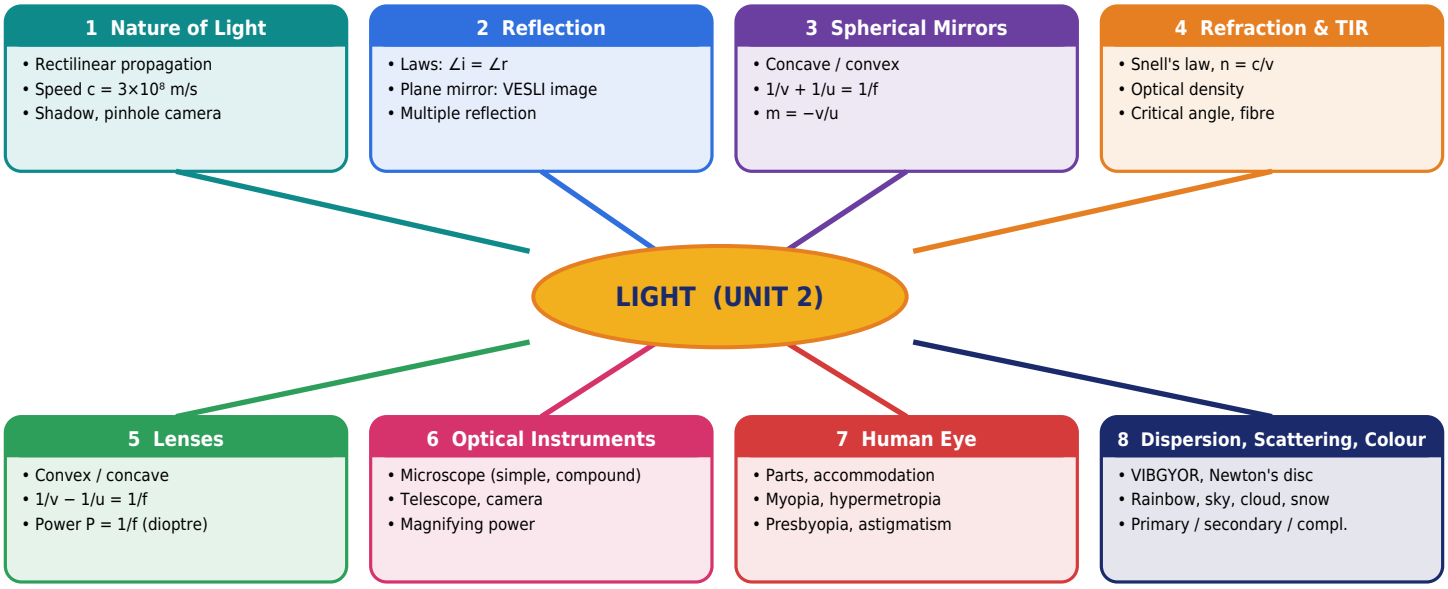
Syllabus statement (K-TET 2012, Physics topic 2)

SYLLABUS

Light : Reflection – plane mirror, spherical mirror, multiple reflection, image formation by spherical mirrors and its applications. Refraction : optical density, total internal reflection and applications. Ray diagram and image formation by lens, lens equation, microscopes, telescope, camera, human eye and common defects of eye and its remedy. Dispersion of light, scattering of light, rainbow, Newton's Disc, colour of sky, cloud, snow. Primary colours, secondary colours – complementary colours.

Syllabus topic	Section	Syllabus topic	Section
Plane mirror, multiple reflection	2	Microscopes, telescope, camera	7
Spherical mirrors & applications	3	Human eye & defects, remedies	8
Refraction, optical density	4	Dispersion, Newton's disc, rainbow	9
Total internal reflection & uses	5	Scattering: sky, cloud, snow	10
Lenses, ray diagrams, lens equation	6	Primary, secondary, complementary colours	11

MAP CONCEPT MAP OF THE UNIT – THE BIG PICTURE



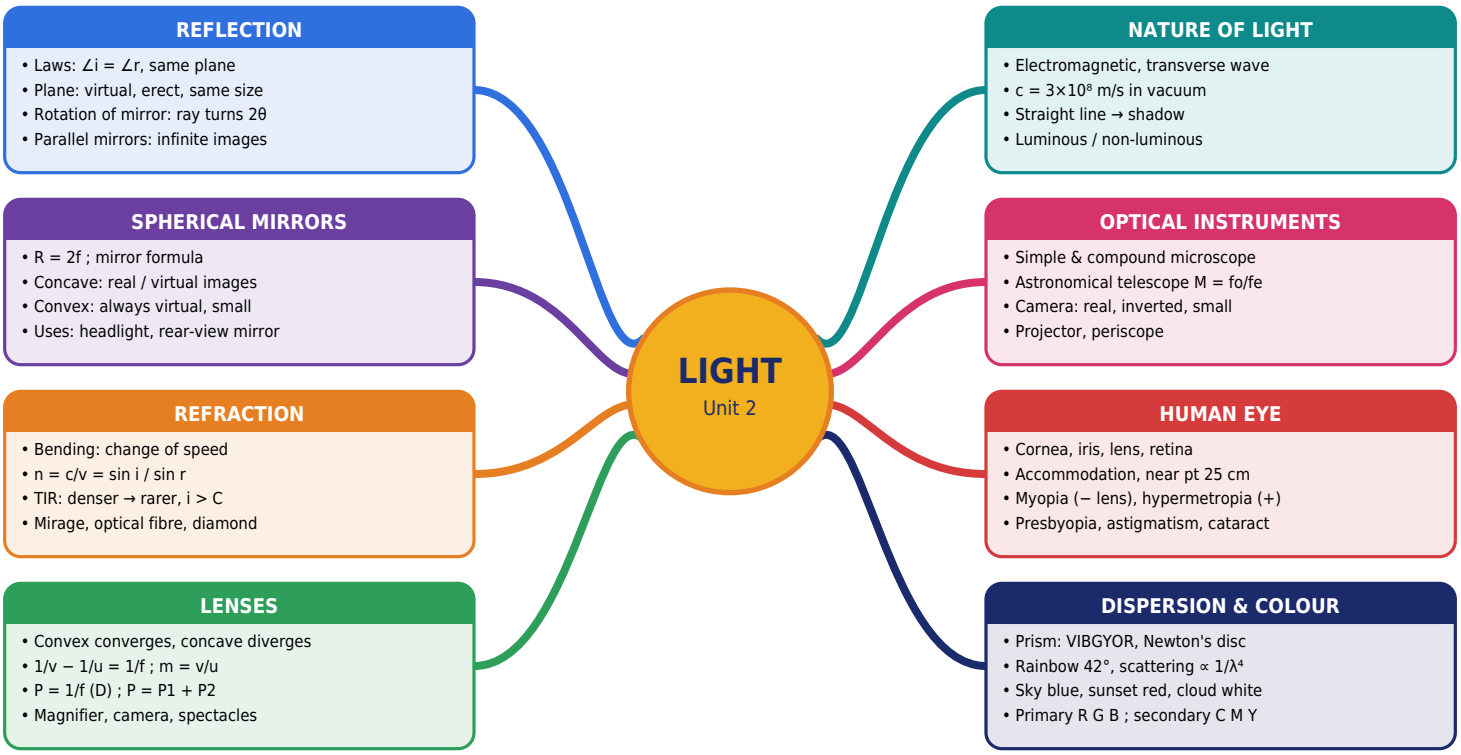
Colour code used in this note

CONCEPT	FORMULA	MEMORY TIP	DAILY LIFE	EXAM ALERT
Core idea / definition	*Equations to remember*	*Mnemonic or trick*	*Where we see it*	*Often asked in exams*

Key numbers to remember

Quantity	Value	Quantity	Value	Quantity	Value
Speed of light, c	3 × 10^8 m/s	Near point of eye	25 cm	n of water / glass	1.33 / 1.5
Sun → Earth	≈ 8 min 20 s	Persistence of vision	≈ 1/16 s	n of diamond	2.42
Visible range	400–700 nm	Primary rainbow angle	≈ 42°	Critical angle: water	48.6°
R and f of mirror	R = 2f	Blue : red scattering	≈ 9 : 1	Critical angle: diamond	24.4°

MIND MAP : LIGHT AT A GLANCE



1 NATURE & PROPAGATION OF LIGHT

Foundation for every other topic

- **Light** is a form of energy that makes objects visible. It is an **electromagnetic, transverse wave** and needs **no medium** (it travels through vacuum).
- Visible light has wavelength about **400 nm (violet) to 700 nm (red)**.
- Speed in vacuum **c = 3 × 10⁸ m/s**; slower in denser media (water ≈ 2.25 × 10^8, glass ≈ 2 × 10^8 m/s).
- Sunlight reaches the Earth in about **8 min 20 s**; moonlight in about 1.3 s.
- **Light year** = distance light travels in one year ≈ 9.46 × 10^{12} km (a unit of distance, not time).
- **Rectilinear propagation:** in a uniform medium light travels in a straight line. Proofs: shadows, pinhole camera, sunbeam through mist, torch beam.
- **Ray** = path of light; **beam** = bundle of rays (parallel, convergent or divergent).

Type	Meaning	Examples
Luminous	Emits its own light	Sun, stars, bulb, candle
Non-luminous	Seen by reflected light	Moon, planets, book, tree
Transparent	Passes light fully	Glass, clear water, air
Translucent	Passes part of light	Butter paper, frosted glass
Opaque	Blocks light	Wood, metal, brick

Shadows and the pinhole camera

- A **shadow** forms when an opaque object blocks light. **Umbra** = region of total darkness; **penumbra** = region of partial darkness.
- A point source gives only an umbra; an **extended source** gives umbra + penumbra. Shadow becomes larger when the object moves closer to the source.
- **Pinhole camera:** a small hole in a dark box forms a **real, inverted** image. Moving the screen away makes the image larger but dimmer.

MEMORY TIP **Light = Line**: if light had not moved in a

DAILY LIFE Sundial (shadow clock) • street-light poles casting long shadows at evening • solar and lunar eclipses are huge shadows • a torch beam in fog or a sunbeam in a dusty room shows straight-line travel • shadow puppetry (Tholpavakoothu of Kerala).

2 REFLECTION OF LIGHT : PLANE MIRROR & MULTIPLE REFLECTION

Concept • laws • diagrams • uses

Reflection is the bouncing back of light into the **same medium** when it falls on a polished surface. Terms: **incident ray**, **reflected ray**, **normal** (perpendicular at the point of incidence), **angle of incidence (i)** and **angle of reflection (r)** (both measured from the normal, not from the surface).

FORMULA **Laws of reflection:** (1) Angle of incidence = angle of reflection (**∠i = ∠r**). (2) The incident ray, the reflected ray and the normal all lie in the **same plane**. These laws hold for every surface, plane or curved. For a ray along the normal, i = 0 and the ray returns along its own path.

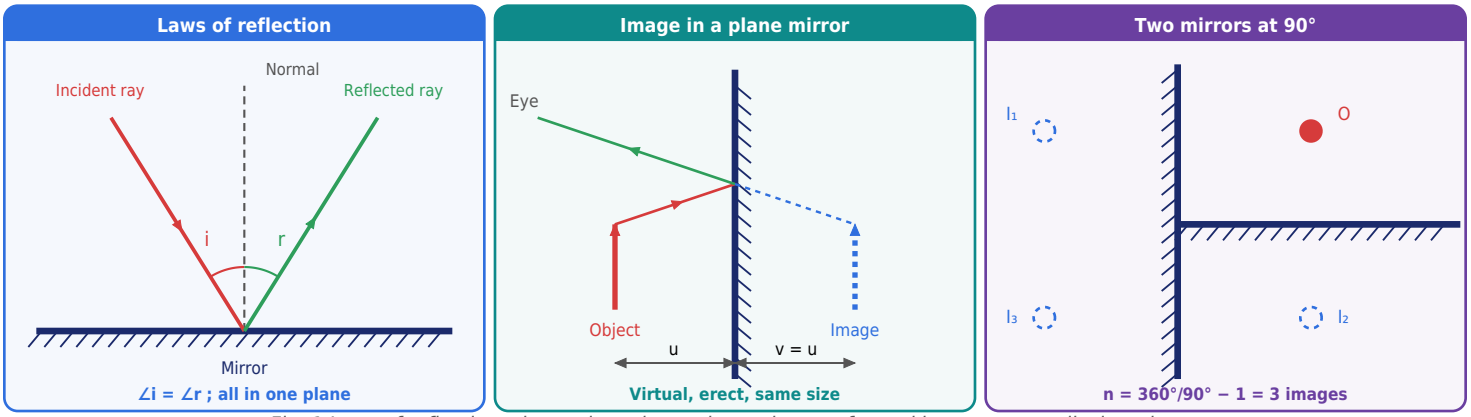


Fig. 1 Laws of reflection • image in a plane mirror • images formed by two perpendicular mirrors

Feature	Regular (specular) reflection	Diffuse (irregular) reflection
Surface	Smooth, polished	Rough, uneven
Reflected rays	Parallel to one another	Scattered in all directions
Image	Clear image is formed	No image; object is only visible
Examples	Mirror, still water, polished steel	Paper, wall, cloth, road, moon's surface

Image formed by a plane mirror

- **VESLI** : **V**irtual, **E**rect, **S**ame size, **L**aterally **I**nverted.
- Image distance behind the mirror = object distance in front (**v = u**); magnification m = +1.
- **Lateral inversion** is left–right reversal, not up–down. Hence **AMBULANCE** is written reversed on the front of the vehicle so that a driver ahead reads it correctly in the rear-view mirror.
- If an object moves towards the mirror at speed v, the image also moves towards it at v; the **relative speed is 2v**.
- Minimum mirror length to see your **full height** = **half your height**, independent of your distance from it.
- If the mirror turns through angle θ (incident ray fixed), the **reflected ray turns through 2θ**.

Multiple reflection (two mirrors inclined at angle θ)

FORMULA Number of images **n = (360°/θ) − 1**

Angle θ	360°/θ	Images
90°	4	3
60°	6	5
45°	8	7
30°	12	11
0° (parallel)	∞	∞

As θ decreases, more images appear. Parallel mirrors give an infinite number of images.

Application	Principle
Periscope (submarine, trenches)	Two plane mirrors parallel and at 45° turn the light path through 90° twice
Kaleidoscope	Three mirrors at 60° form multiple images of coloured bits → symmetric patterns
Barber's shop	Two parallel mirrors facing each other give a series of images

MEMORY TIP Parallel mirrors: **infinite** images. Perpendicular mirrors: **3**. Remember **"Take 360, divide by angle, subtract 1"**.

DAILY LIFE Rear-view mirror • dressing mirror (half-height rule) • mirrors in shops and lifts to look bigger • dentist's mirror • glass buildings reflecting sunlight • ripples destroy the clear image on water because the surface becomes uneven.

3 SPHERICAL MIRRORS : CONCAVE & CONVEX

Terms • sign convention • image formation • uses

A **spherical mirror** is a part of a hollow sphere whose one side is polished.
Concave mirror: the inner (hollow) surface reflects – *converging* mirror.
Convex mirror: the outer (bulging) surface reflects – *diverging* mirror.

- **Pole (P)**: centre of the mirror surface.
- **Centre of curvature (C)**: centre of the sphere; **radius R** = PC.
- **Principal axis**: line through P and C.
- **Principal focus (F)**: point where rays parallel to the axis meet (concave, real) or appear to come from (convex, virtual).
- **Focal length f** = PF ; **R = 2f** for small apertures.
- **Aperture**: width of the mirror surface.

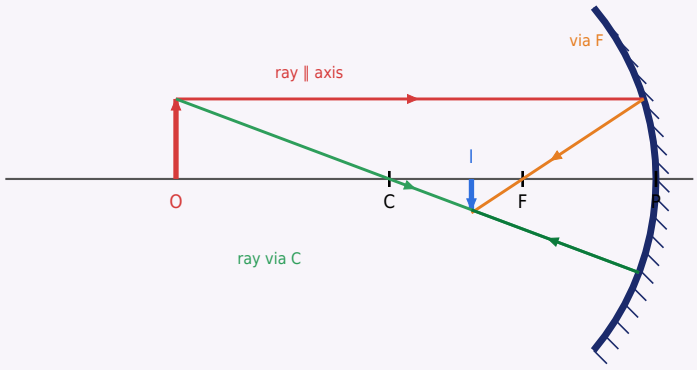
Rules for drawing rays

- Ray **parallel** to axis → passes through **F** (concave) / appears to come from F (convex).
- Ray through **F** → reflects **parallel** to axis.
- Ray through **C** (or directed to C) → returns along the **same path**.
- Ray hitting **P** → reflects with ∠i = ∠r about the axis.

FORMULA — **New Cartesian sign convention:** measure all distances from the pole P. Distances in the direction of the incident light are **+**; against it **−**. Heights above the axis +, below −. **Concave**: f and R negative. **Convex**: f and R positive. Real object: u negative.

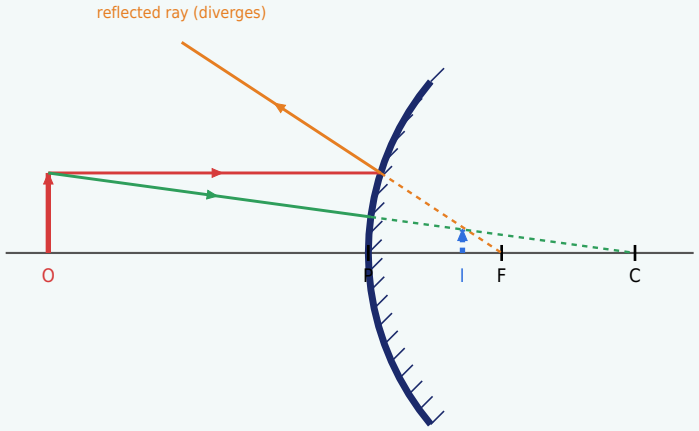
FORMULAS — **Mirror formula: 1/v + 1/u = 1/f** | **Magnification m = h′/h = −v/u** | m negative → real & inverted ; m positive → virtual & erect ; |m| > 1 enlarged.

Concave mirror : object beyond C



Real, inverted, diminished (between C and F)

Convex mirror : any position



Virtual, erect, diminished (behind mirror)

Fig. 2 Image formation by a concave mirror (object beyond C) and a convex mirror

Image formation – concave mirror

Object position	Image position	Size	Nature
At infinity	At F	Highly diminished (point)	Real, inverted
Beyond C	Between F and C	Diminished	Real, inverted
At C	At C	Same size	Real, inverted
Between C and F	Beyond C	Enlarged	Real, inverted
At F	At infinity	Highly enlarged	Real, inverted
Between F and P	Behind the mirror	Enlarged	**Virtual, erect**
Convex: anywhere	Between P and F (behind)	Diminished	**Virtual, erect**

Worked examples

(a) Concave mirror f = −10 cm, object at 20 cm: u = −20. 1/v = 1/f − 1/u = −1/10 + 1/20 = −1/20 ⇒ **v = −20 cm**; m = −v/u = −1 ⇒ real, inverted, same size at C.

(b) Convex mirror f = +15 cm, object at 30 cm: 1/v = 1/15 + 1/30 = 1/10 ⇒ **v = +10 cm**; m = +1/3 ⇒ virtual, erect, one-third size.

Uses of spherical mirrors

- **Concave:** shaving / make-up mirror (object within F → magnified erect image), dentist's mirror, torch & vehicle headlight reflectors, solar cooker, reflecting telescopes.
- **Convex:** rear-view mirrors (wide field of view, erect image), street-light reflectors, shop security mirrors, mirrors at sharp road bends.

MEMORY TIP — Convex mirror = **"C"**onvex → **C**an see more (**always virtual, erect, small**, wide view). Concave mirror: inside F gives a big erect image (shaving mirror); outside F gives a real inverted image.

EXAM ALERT — Image of an object placed at infinity in a concave mirror lies at **F**. Convex mirror image is **never** real. R = 2f.

4 REFRACTION & OPTICAL DENSITY

Bending of light • Snell's law • refractive index

Refraction is the bending of light when it passes obliquely from one transparent medium to another, because its **speed changes**.

- Rarer → denser: ray bends **towards** the normal (i > r). Denser → rarer: bends **away** from the normal.
- Along the normal (i = 0) there is **no bending**, though the speed still changes.
- **Frequency does not change**; speed and wavelength change.
- **Optical density** = ability of a medium to slow light. It is **not** the same as mass density: kerosene floats on water yet is optically denser (n = 1.44 vs 1.33).
- **Apparent depth** = real depth / n. A pond looks about 3/4 as deep as it really is; a pencil in water looks bent.

SNELL'S LAW

sin i / sin r = n_{21} = n_2/n_1
Absolute index **n = c / v** (speed of light in vacuum / in medium). Always n ≥ 1.

Medium	n
Air	1.0003
Ice	1.31
Water	1.33
Kerosene	1.44
Crown glass	1.52
Ruby	1.71
Diamond	2.42

Glass slab: the emergent ray is **parallel** to the incident ray but shifted sideways (lateral displacement d). d increases with thickness of the slab, the angle of incidence and the refractive index.

5 TOTAL INTERNAL REFLECTION (TIR) & APPLICATIONS

Critical angle • mirage • fibre • diamond

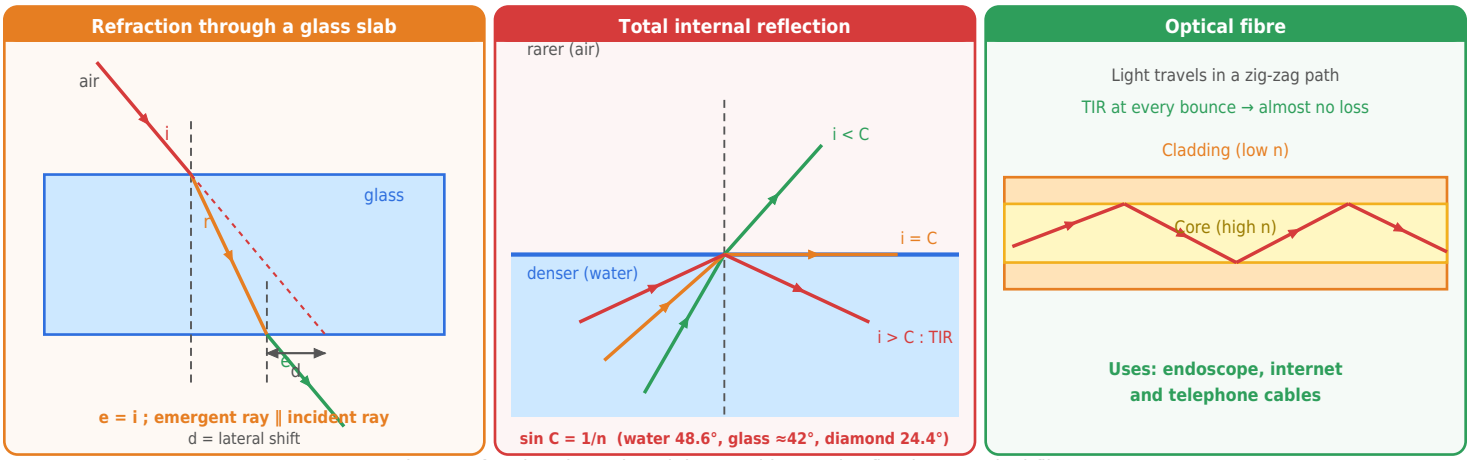


Fig. 3 Refraction through a slab • total internal reflection • optical fibre

TIR CONDITIONS

(1) Light goes from a **denser to a rarer** medium. (2) Angle of incidence is **greater than the critical angle C**.
sin C = 1/n (n of denser medium w.r.t. rarer). Larger n → smaller C.

Critical angle C = the angle of incidence in the denser medium for which the refracted ray grazes the boundary (angle of refraction = 90°).

Application	How TIR helps
Diamond	C = 24.4°, so light is trapped and bounces many times → sparkle
Optical fibre	Core (high n) + cladding (low n); signal travels with almost no loss
Mirage	Hot air near ground is rarer; light from sky bends up (TIR) → "water" on road
Prism reflectors	Binoculars, periscope: 45° prism turns light by 90° or 180°
Air bubble / test tube	Shines silvery when viewed from the side in water

MEMORY TIP **TIR needs "D→R and i > C"** – **D**enser **to R**arer. Rarer-to-denser Towards normal: **"RDT"** (Rarer–Denser–Towards).

DAILY LIFE Endoscopy and internet cables use fibres • desert/road mirage in summer • stars twinkle and the Sun is seen ~2 minutes before actual sunrise (atmospheric refraction) • a coin in a cup appears when water is poured in • fish appear nearer the surface • sparkling of cut-glass and diamond jewellery.

6 LENSES : RAY DIAGRAMS & LENS EQUATION

Convex • concave • power • image formation

A **lens** is a transparent refracting medium bounded by two spherical surfaces. **Convex** (thick at the centre) *converges* parallel light. **Concave** (thin at the centre) *diverges* it.

- **Optical centre (O)**: centre of the lens; a ray through O goes **undeviated**.
- **Principal foci F_1, F_2** (one on each side); **focal length f** = OF.
- **Centres of curvature**: 2F points are used in ray diagrams for thin lenses.
- Types: biconvex, plano-convex, concavo-convex; biconcave, plano-concave, convexo-concave.

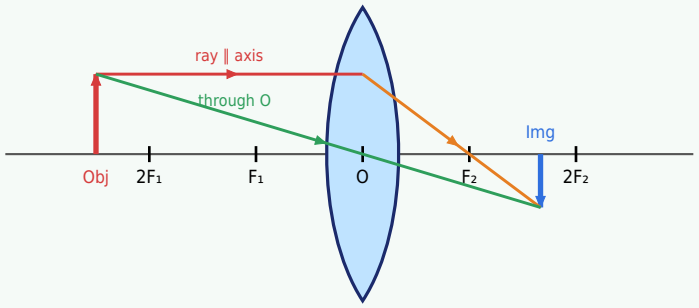
Three rules for drawing rays

- Ray **parallel** to axis → passes through (convex) / appears from (concave) the **second focus F_2**.
- Ray through **first focus F_1** → emerges **parallel** to the axis.
- Ray through the **optical centre** → goes straight, undeviated.

FORMULAS **Lens formula $1/v - 1/u = 1/f$** | **$m = h'/h = v/u$** | **Power $P = 1/f$** (f in metre; unit **dioptre, D**) | Lenses in contact: **$P = P_1 + P_2$** | Lens-maker: $1/f = (n-1)(1/R_1 - 1/R_2)$

Sign convention: same as for mirrors. **Convex**: f +, P +. **Concave**: f −, P −. A +2 D lens has f = +50 cm.

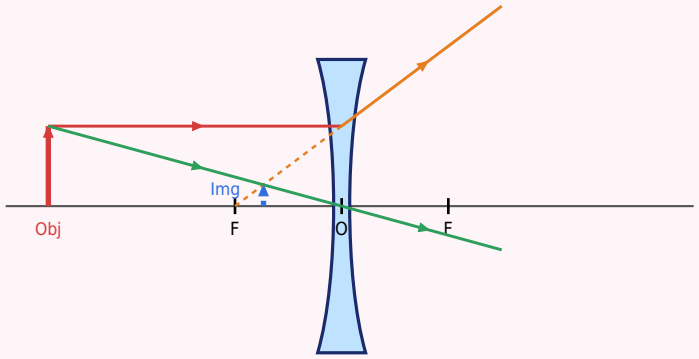
Convex lens : object beyond $2F_1$



Same as concave mirror, but image on the other side

Real, inverted, diminished (between F_2 and $2F_2$)

Concave lens : any position



Dashed lines = virtual (not real) path of light

Virtual, erect, diminished (same side as object)

Fig. 4 Image formation by a convex lens and by a concave lens

Image formation – convex lens

Object position	Image position	Size	Nature
At infinity	At F_2	Highly diminished	Real, inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real, inverted
At $2F_1$	At $2F_2$	Same size	Real, inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real, inverted
At F_1	At infinity	Highly enlarged	Real, inverted
Between F_1 and O	Same side as object	Enlarged	**Virtual, erect** (magnifier)
Concave lens: anywhere	Between O and F (object side)	Diminished	**Virtual, erect**

Worked example

A convex lens has f = 10 cm. An object is 15 cm away. u = −15 cm. $1/v = 1/f + 1/u = 1/10 - 1/15 = 1/30 \Rightarrow$ **v = +30 cm**. $m = v/u = 30/(-15) =$ **−2** ⇒ real, inverted, twice the size.

Uses

- **Convex:** magnifying glass, camera, projector, microscope, telescope, spectacles for hypermetropia, burning glass.
- **Concave:** spectacles for myopia, door peep-hole (with convex), wide-angle torch.

MEMORY TIP **Convex lens ≈ concave mirror** (both converge; real inverted images, virtual inside F). **Concave lens ≈ convex mirror** (both diverge; always virtual, erect, small). Spectacles: **Minus lens for Myopia, Plus lens for hypermetropia**.

DAILY LIFE Reading glasses • camera phone lens • burning paper with sunlight through a lens • a water drop on a leaf magnifies veins • projector in cinema/class • lighthouse (Fresnel lens) • magnifier of watch-repairers and jewellers.

7 OPTICAL INSTRUMENTS : MICROSCOPE, TELESCOPE, CAMERA

Construction • working • magnification

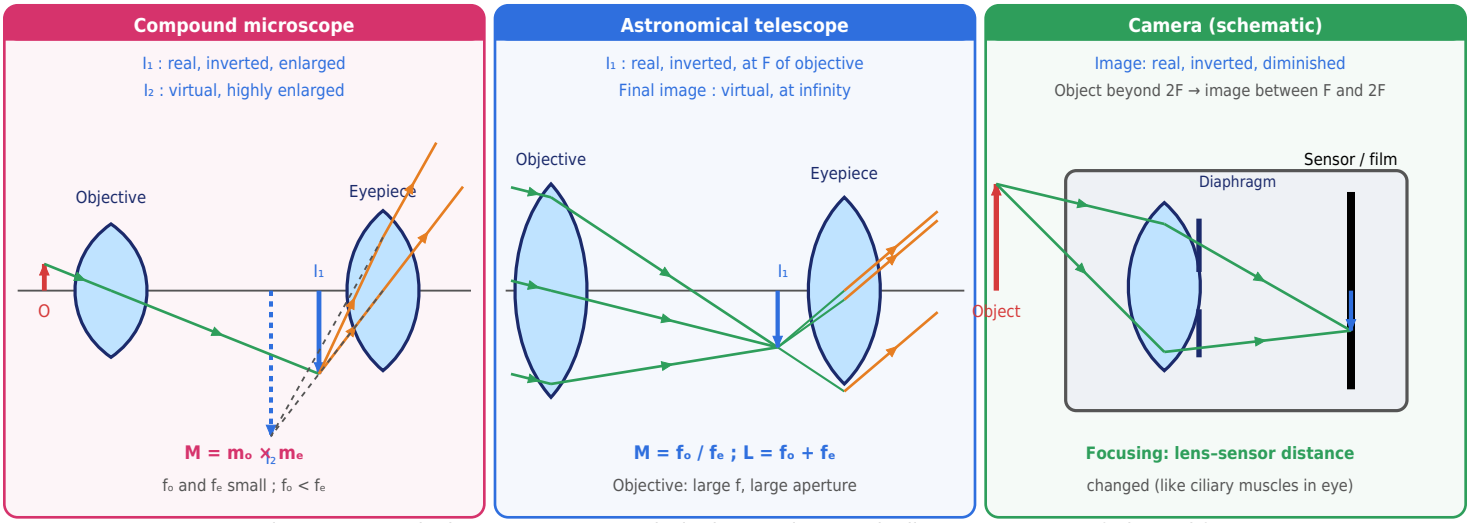


Fig. 5 Compound microscope • astronomical telescope in normal adjustment • camera (schematic)

Simple microscope (magnifying glass)

- A single convex lens of **short focal length**; object placed **within F → virtual, erect, enlarged** image.
- **M = 1 + D/f** (image at near point D = 25 cm); **M = D/f** when the image is at infinity (relaxed eye).
- Used by watch-repairers, jewellers, stamp collectors, readers of fine print.

Compound microscope

- Two convex lenses: **objective** (very short f, small aperture, near the object) and **eyepiece** (larger f).
- Object just beyond F_o → first image I_1 real, inverted, enlarged, inside F_e → final image I_2 **virtual, inverted (w.r.t. object), highly enlarged**.
- **$M = m_o \times m_e \approx (L/f_o)(D/f_e)$**, L = tube length. Used to see cells, bacteria, tissues.

Astronomical telescope

- **Objective:** large aperture and long f (gathers more light). **Eyepiece:** short f.
- Normal adjustment: final image at infinity; **$M = f_o/f_e$**; tube length **$L = f_o + f_e$**. Image is inverted.
- **Terrestrial telescope** adds an erecting lens/prism (upright image). **Galilean** type has a concave eyepiece.
- **Reflecting telescope** uses a concave **mirror** as the objective (no colour fringes, lighter, larger): Hubble (2.4 m), James Webb (6.5 m).

Camera & projector

- Camera: light-tight box, convex lens, **diaphragm** (controls brightness), shutter (exposure time), film/sensor.
- Object beyond 2F → image between F and 2F: **real, inverted, diminished**. Focus by changing lens–sensor distance.
- **Projector:** slide just beyond F (upside down) → large, real, inverted image on the screen.
- **Pinhole camera** needs no lens; image is dim but always in focus.

Instrument	Lens / mirror used	Final image	Magnification
Simple microscope	One convex lens (short f)	Virtual, erect, enlarged	1 + D/f
Compound microscope	Two convex lenses, $f_o < f_e$	Virtual, inverted, enlarged	$m_o \times m_e$
Astronomical telescope	Convex, $f_o > f_e$ (or concave mirror)	Virtual, inverted (at ∞)	f_o / f_e
Camera	Convex lens + sensor	Real, inverted, diminished	m = v/u (< 1)
Projector	Convex lens	Real, inverted, enlarged	m = v/u (> 1)

Worked examples

(a) Magnifier f = 5 cm. Image at near point: M = 1 + 25/5 = **6**. Image at infinity: M = 25/5 = **5**.

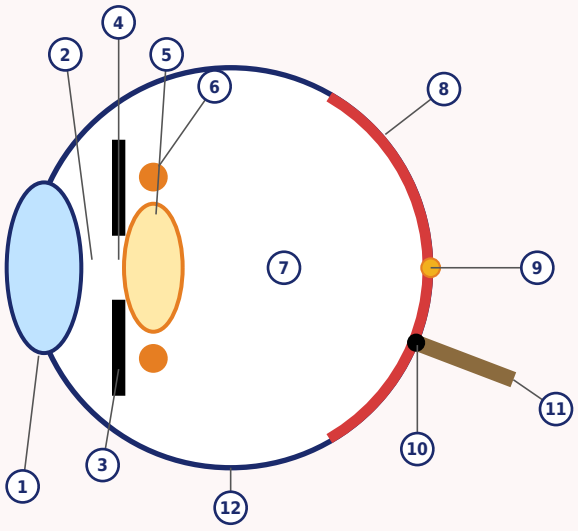
(b) Telescope f_o = 100 cm, f_e = 5 cm: M = 100/5 = **20**; tube length L = 100 + 5 = **105 cm**. **(c)** A larger objective aperture gathers more light, so faint stars become visible.

MEMORY TIP Microscope: **Objective is Obsessed with small f** (near the object). Telescope: **Objective is Big** (large aperture and long f). M of telescope = **fo over fe**.

DAILY LIFE Pathology lab slides • observatory telescopes • DSLR and mobile cameras • CCTV • binoculars at a match • slide/LCD projectors • doctor's magnifying loupe • eye (a natural camera) – see the next page.

8 THE HUMAN EYE & COMMON DEFECTS OF VISION

Structure • accommodation • defects • remedies



PARTS OF THE HUMAN EYE

1 Cornea
2 Aqueous humour
3 Iris
4 Pupil
5 Eye lens
6 Ciliary muscles
7 Vitreous humour
8 Retina
9 Yellow spot (fovea)
10 Blind spot
11 Optic nerve
12 Sclera

EYE ≈ CAMERA

Cornea + lens = lens system
Iris / pupil = diaphragm (aperture)
Retina = film / sensor
Ciliary muscles = focusing ring
Image on retina: real, inverted, small

Fig. 6 Section of the human eye (numbers refer to the list on the right)

Part	Function
Cornea	Transparent front bulge; **most of the refraction** (about two-thirds) occurs here
Iris & pupil	Iris (coloured muscle) changes pupil size: small in bright light, large in dim light
Eye lens & ciliary muscles	Flexible biconvex lens; ciliary muscles change its curvature for **fine focusing**
Retina	**Rods**: dim light, black & white. **Cones**: bright light, colour. Forms a real, inverted, small image
Yellow spot / blind spot	Yellow spot: most cones, sharpest vision. Blind spot: where optic nerve leaves; no receptors
Aqueous & vitreous humour	Transparent fluids; maintain shape and pressure of the eyeball and help in refraction

Accommodation: the ability of the eye lens to change its focal length. To see **near** objects the ciliary muscles **contract** → lens thicker, f smaller. For **distant** objects they relax → lens thinner, f larger.

Normal vision: near point = **25 cm**, far point = **infinity**. **Persistence of vision** ≈ 1/16 s: why cinema (24 frames/s) and a spinning Newton's disc look continuous.

POWER OF LENS

Myopia: f = −(far point distance). Far point 2 m ⇒ f = −2 m, **P = −0.5 D**.
Hypermetropia: lens that forms the image of a 25 cm object at the near point.

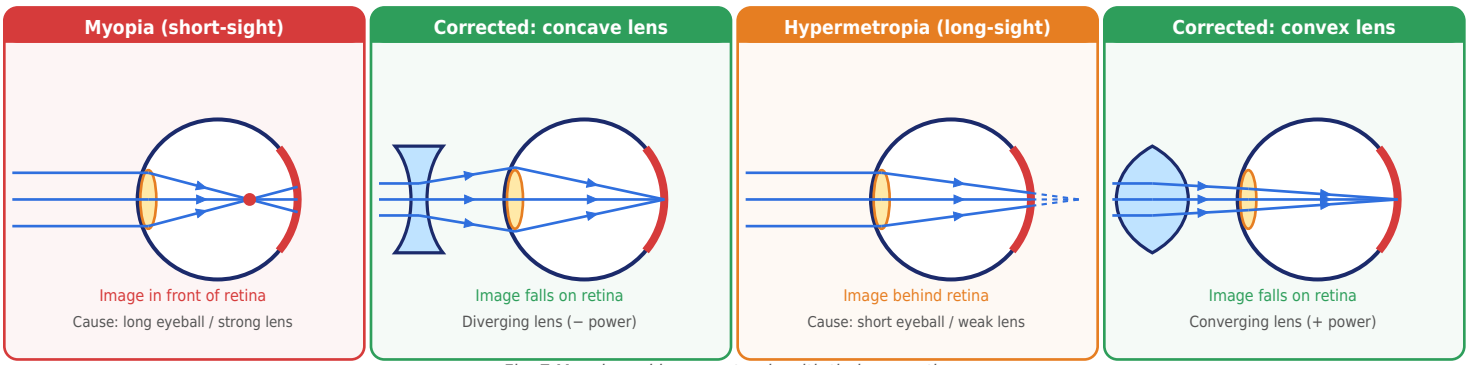


Fig. 7 Myopia and hypermetropia with their corrections

Defect	Cause	Symptom	Remedy
Myopia (near-sight)	Long eyeball / strong lens	Distant objects blurred; near point normal	**Concave** (−) lens
Hypermetropia (far-sight)	Short eyeball / weak lens	Near objects blurred; near point > 25 cm	**Convex** (+) lens
Presbyopia	Ageing: weak ciliary muscles	Both near and far vision poor	Bifocal lens (concave above, convex below)
Astigmatism	Cornea not perfectly spherical	Lines in one direction look blurred	**Cylindrical** lens
Cataract	Eye lens becomes cloudy	Hazy vision	Surgery, artificial intraocular lens
Colour blindness	Defective cones (genetic)	Red–green confusion most common	No cure (Ishihara test detects)

DAILY LIFE

Spectacles and contact lenses • Vitamin A (carrot, papaya, leafy vegetables) prevents night blindness • follow the 20-20-20 rule for screens • eye donation gives the **cornea** to a corneal-blind person.

9 DISPERSION OF LIGHT, NEWTON'S DISC & RAINBOW

Prism • spectrum • VIBGYOR

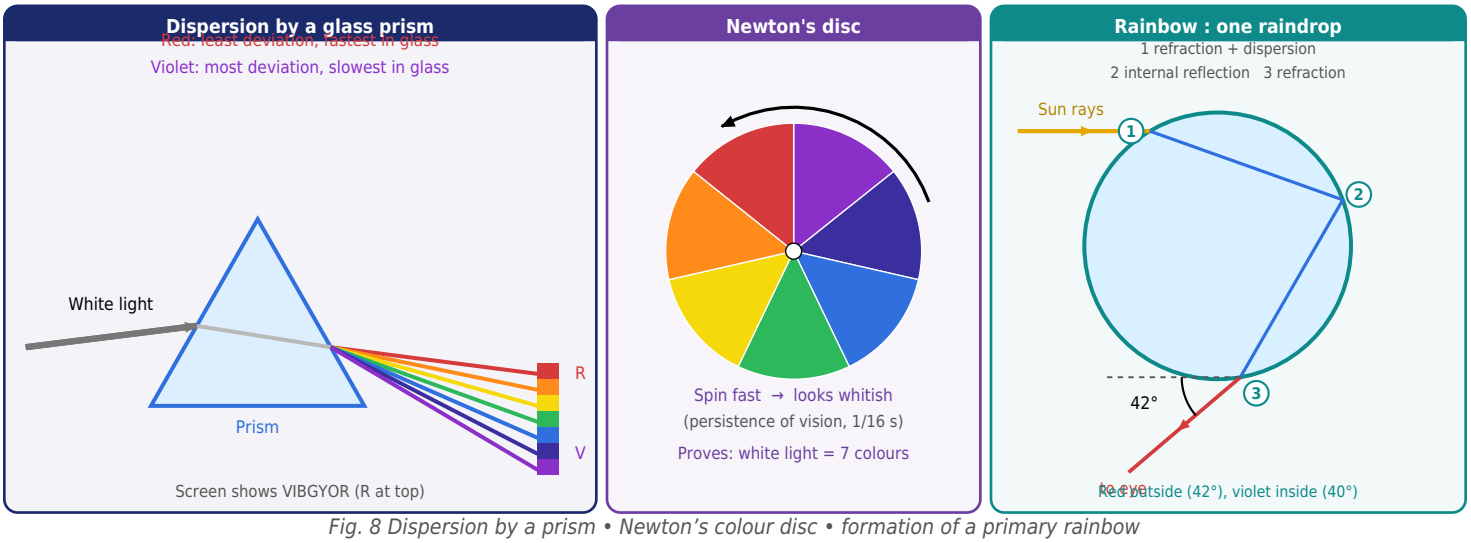


Fig. 8 Dispersion by a prism • Newton's colour disc • formation of a primary rainbow

Dispersion is the splitting of white light into its seven colours when it passes through a prism. It happens because the **refractive index depends on colour**: violet has the highest n (bends most), red the lowest (bends least). In a vacuum all colours travel at the same speed.

- Colours in order: **V I B G Y O R** (violet, indigo, blue, green, yellow, orange, red).
- **Newton (1666)** showed that a second, inverted prism **recombines** the colours into white light – so the prism does not create colours.
- **Newton's disc:** a disc painted with the seven colours looks **whitish** when spun fast (persistence of vision).

Rainbow

- Formed by **refraction + dispersion + internal reflection** of sunlight in raindrops.
- Seen when the **Sun is behind the observer** and rain is in front; the Sun must be low.
- **Primary bow:** one internal reflection; red outside (42°), violet inside (40°).
- **Secondary bow:** two internal reflections; fainter, colours **reversed** (red inside), about 51°.
- Also seen in waterfalls, fountains, garden sprinklers.

10 SCATTERING OF LIGHT : COLOUR OF SKY, CLOUD & SNOW

Tyndall effect • Rayleigh scattering

Scattering is the redirection of light in all directions by particles in its path. **Tyndall effect**: a beam of light becomes visible when it is scattered by colloidal particles (smoke, mist, dust, fine droplets).

MEMORY TIP Short wavelength scatters most: **"Blue Beat** lamps – it travels farthest.

FORMULA **Rayleigh:** for particles smaller than the wavelength, scattered intensity ∝ $\mathbf{1/\lambda^4}$. Blue (≈ 400–450 nm) scatters about **9 times** more than red (≈ 700 nm).

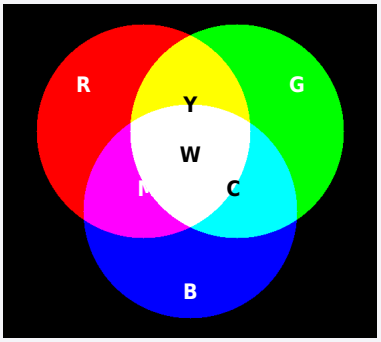
Observation	Scientific reason
Sky is blue	Air molecules scatter short wavelengths (blue) most; blue light reaches our eyes from all directions
Why not violet?	Sun emits less violet, upper atmosphere absorbs some, and our eye is less sensitive to violet
Sun red at sunrise & sunset	Light travels a longer path through air; most blue is scattered away, red reaches us
Sun white at noon	Shorter path; little scattering, all colours reach us together
Sky black for astronauts	No atmosphere in space → no scattering
Clouds are white	Water droplets are larger than the wavelength and scatter **all colours nearly equally**
Snow is white	Many tiny ice crystals reflect and scatter all colours repeatedly in every direction
Deep sea looks blue	Water absorbs red and scatters blue

DAILY LIFE Red traffic and danger signals • orange-red sunsets over the Arabian Sea at Kozhikode and Kovalam • beam of a projector in a smoky hall • sunbeams through forest mist (Tyndall effect) • milk and clouds look white.

11 COLOURS : PRIMARY, SECONDARY & COMPLEMENTARY

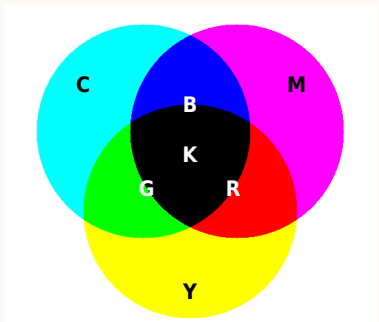
Mixing of light • mixing of pigments

Additive mixing (light)



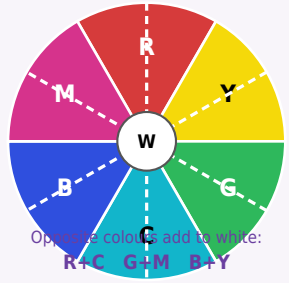
R + G + B = White

Subtractive mixing (pigments)



C + M + Y = Black (K)

Complementary colour wheel



Each pair = primary + secondary

Fig. 9 Additive mixing of coloured light • subtractive mixing of pigments • complementary colours

Colours of light (additive)

- **Primary colours: Red**, **Green**, **Blue** – none can be made by mixing the others.
- **Secondary colours** (mix of two primaries): R + G = **Yellow**; G + B = **Cyan**; R + B = **Magenta**.
- R + G + B = **White**.
- **Complementary colours**: two colours that give **white** when added – **Red–Cyan, Green–Magenta, Blue–Yellow** (a primary with the secondary made from the other two).

Colours of pigments (subtractive)

- **Primary pigments:** Cyan, Magenta, Yellow (each *subtracts* some colours from white light).
- C + M = Blue; C + Y = Green; M + Y = Red; C + M + Y = **Black** (printing adds K: **CMYK**).
- Painters' traditional primaries are red, yellow, blue.
- **Colour of an opaque object** = colour it reflects; of a **transparent** object = colour it transmits. White reflects all; black absorbs all.

Colour	Wavelength (approx.)	Colour	Wavelength (approx.)
Violet	380–450 nm	Yellow	570–590 nm
Blue (incl. indigo)	450–495 nm	Orange	590–620 nm
Green	495–570 nm	Red	620–750 nm

Object	Seen in white light	Seen in red light	Seen in green light
Red rose	Red	Red	Black
White shirt	White	Red	Green
Green leaf	Green	Black	Green
Yellow flag	Yellow	Red	Green
Blue book	Blue	Black	Black

MEMORY TIP **RGB = Light, CMY = Colour paint**: "Light is Additiv

EXAM ALERT A red rose in **green** light looks **black**; a yellow object in blu

"RiCe, GoM, BuY".

How we see colour

- The retina has three kinds of **cones**, most sensitive to red, green and blue light; the brain mixes their signals to give every colour.
- Colour of light depends on **frequency** (not wavelength in a medium): red has the lowest, violet the highest frequency.

Colour filters (transmit only their own colour)

Filter	Transmits	Absorbs
Red	Red	Green, blue
Yellow	Red + green	Blue
Cyan	Green + blue	Red
Magenta	Red + blue	Green

DAILY LIFE TV, mobile and computer screens use RGB pixels • printers use CMYK inks • stage lights and colour filters • surgeons wear green/blue gowns (complementary to red blood, reduces eye strain) • afterimage: stare at red, then see cyan • mixing paints in art class.

12 DIFFERENTIATION TABLES (DIFFERENCE BETWEEN…)

Frequently tested contrasts

1. Concave mirror vs convex mirror

Point	Concave mirror	Convex mirror
Reflecting surface	Inner (hollow) surface	Outer (bulging) surface
Action on parallel beam	Converges	Diverges
Focus / f (Cartesian)	Real, in front; f negative	Virtual, behind; f positive
Images	Real & inverted, or virtual & erect (inside F)	Always virtual, erect, diminished
Uses	Shaving mirror, headlight, solar cooker	Rear-view mirror, security mirror

2. Convex lens vs concave lens

Point	Convex lens	Concave lens
Shape	Thick at centre, thin at edges	Thin at centre, thick at edges
Action	Converging	Diverging
Focal length & power	Positive	Negative
Images	Real or virtual; may be enlarged	Always virtual, erect, diminished
Use	Hypermetropia, magnifier, camera	Myopia correction

3. Reflection vs refraction

Point	Reflection	Refraction
Medium	Light returns to the same medium	Light enters a second medium
Speed	Unchanged	Changes
Law	∠i = ∠r	sin i / sin r = constant
Example	Mirror image	Pencil bent in water

4. Real image vs virtual image

Point	Real image	Virtual image
Formed by	Actual meeting of rays	Apparent meeting (extended back)
On screen?	Yes	No
Orientation	Usually inverted	Erect
Example	Cinema screen, camera	Plane mirror, magnifier

5. Myopia vs hypermetropia

Point	Myopia	Hypermetropia
Also called	Short-sight	Long-sight
Image	In front of retina	Behind retina
Cannot see	Distant objects	Near objects
Lens	Concave	Convex

6. Additive vs subtractive mixing

Point	Additive	Subtractive
Mixing of	Coloured light	Pigments / dyes
Primaries	R, G, B	C, M, Y
All together	White	Black
Used in	TV, mobile screens	Printing, painting

7. Rods vs cones

Point	Rods	Cones
Light	Dim light	Bright light
Vision	Black & white	Colour
Position	Mostly periphery	Concentrated at fovea

8. Dispersion vs scattering

Point	Dispersion	Scattering
Cause	n varies with colour	Particles redirect light
Needs	Prism / raindrop	Air, dust, droplets
Example	Spectrum, rainbow	Blue sky, red sunset

F FORMULA SHEET

Topic	Formula	Topic	Formula
Law of reflection	∠i = ∠r	Snell's law	$\sin i / \sin r = n_2/n_1$
Rotated mirror	Ray turns 2θ	Refractive index	n = c / v
Two mirrors at θ	$n = 360°/\theta - 1$	Critical angle	sin C = 1/n
Mirror formula	1/v + 1/u = 1/f ; R = 2f	Lens formula	1/v − 1/u = 1/f
Mirror magnification	m = −v/u	Lens magnification	m = v/u
Power of lens	P = 1/f (D)	Lenses in contact	$P = P_1 + P_2$
Telescope	$M = f_o/f_e$; $L = f_o + f_e$	Magnifier	M = 1 + D/f ; D = 25 cm

13 MEMORY TIPS & MNEMONICS

Quick tricks for the exam hall

Plane mirror image **VESLI** – Virtual, Erect, Same size, Laterally Inverted.	**Spectrum order** **VIBGYOR** (violet → red). Reverse: **ROY G BIV**.
Deviation in prism **V**iolet is **V**ery bent (most); **R**ed is **R**elaxed (least).	**Bending direction** **RDT**: Rarer → Denser → **T**owards the normal.
TIR conditions **D→R** and **i > C**: Denser to Rarer, bigger than critical.	**Spectacles** **M**yopia → **M**inus (concave); **H**ypermetropia → **H**igh/plus (convex).
Sign convention Direction of incident light is **positive**; concave mirror f is **negative**, convex mirror f is **positive**.	**Twins** Concave mirror ≈ convex lens; convex mirror ≈ concave lens (same image behaviour).
Additive primaries **RGB** for light; **CMY** for paints. Complementary pairs: **RC, GM, BY**.	**Rayleigh** Scattering $\propto 1/\lambda^4$: **Blue Beats Red** (≈ 9 times).
Rainbow **Sun behind, rain ahead**; red on the outside of the primary bow.	**Mirror pairs** **360 ÷ angle − 1** gives the number of images.

14 LIGHT IN DAILY LIFE : PHENOMENON → CONCEPT

Everyday observation	Concept	Everyday observation	Concept
Bathroom mirror	Plane mirror, virtual image	Rear-view mirror of a bike	Convex mirror
Shaving mirror	Concave mirror, F > u	Headlight of a car	Concave mirror reflector
Pencil looks bent in water	Refraction	Swimming pool looks shallow	Apparent depth
Diamond sparkle	TIR, small critical angle	Mirage on hot road	TIR / refraction
Spectacles, camera	Lens	Cinema projector	Convex lens, real image
Rainbow after rain	Dispersion + TIR	Blue sky, red sunset	Rayleigh scattering
Beam in a dusty room	Tyndall effect	Stars twinkle	Atmospheric refraction
Colour TV pixels	RGB additive mixing	Colour printer	CMYK subtractive

Q QUICK PRACTICE (K-TET STYLE) – ANSWERS IN BRACKETS

1. The image formed by a plane mirror is: **(virtual, erect, same size, laterally inverted)**	9. Defect corrected by a concave lens: **(myopia)**
2. Two mirrors are inclined at 60°. Number of images of a point object: **(5)**	10. Magnifying power of an astronomical telescope with f_o = 100 cm, f_e = 5 cm: **(20)**
3. Mirror used in the headlight of a vehicle: **(concave)**	11. Colour that is least scattered by the atmosphere: **(red)**
4. Concave mirror, f = 15 cm. Object at C gives image at: **(C, i.e. 30 cm, same size)**	12. Complementary colour of yellow: **(blue)**
5. Refractive index of a medium in which light travels at 2×10^8 m/s: **(n = 3/2 = 1.5)**	13. Secondary colours of light: **(cyan, magenta, yellow)**
6. Critical angle for a medium of n = 2: **(30°, since sin C = 1/2)**	14. Light from the Sun reaches the Earth in about: **(8 min 20 s)**
7. Power of a lens with f = −25 cm: **(−4 D, concave)**	15. If a mirror rotates by 15°, the reflected ray turns by: **(30°)**
8. A convex lens forms a real image of the same size when the object is at: **(2F)**	

✓ LAST-MINUTE REVISION CHECKLIST

☐ Laws of reflection; VESLI; $n = 360/\theta - 1$	☐ Microscope and telescope magnification; camera image
☐ Sign convention; mirror and lens formula; R = 2f	☐ Eye parts, accommodation, myopia / hypermetropia remedies
☐ Image tables for concave mirror and convex lens	☐ Dispersion, Newton's disc, rainbow order, Rayleigh $1/\lambda^4$
☐ Snell's law, n = c/v, sin C = 1/n, TIR uses	☐ Sky, sunset, cloud, snow reasons
☐ Power in dioptre; $P = P_1 + P_2$	☐ Primary, secondary, complementary colours; additive vs subtractive