Final Exam Revision
Physics 10 - Advanced Stream

Term 3 - Academic Year 2025-2026

UAE Inspire Science Physics - Refraction, Lenses, Wave Optics, Relative Motion
Aligned with Haykal (Term 3 Centralized Exam Scope)

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Subject: Physics (Inspire) - Advanced Stream
Exam: Term 3 Final - 120 min - 25 MCQ - Calculator allowed

How to use this revision guide

1. Study the **Formula Sheet** and **Concepts Summary** (next pages).
2. Work through **Topics 1-5** in textbook order (pages 90-96, 98-106, 112-126, 148-152).
3. Answer each question before reading the low-contrast solutions.
4. Past MOE marks questions from previous Ministry exams.
5. Textbook marks questions from the Inspire Physics book.

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Formula Sheet & Symbol Guide

All formulas below are on the **Haykal** (Term 3 Final Exam scope). Symbols are defined before you substitute values.

Formula	Symbols & Units	When to Use
$n_1 \sin\theta_1 = n_2 \sin\theta_2$	n_1, n_2: index of refraction θ_1: angle of incidence θ_2: angle of refraction	Snell's law at a boundary between two media.
$n = \frac{c}{v}$	n: index of refraction $c \approx 3.00 \times 10^8 \quad \mathrm{m/s}$ in vacuum v: speed of light in the medium	Find n or v; compare how much light slows in a material.
$\frac{n_1}{n_2} = \frac{v_2}{v_1} = \frac{\lambda_1}{\lambda_2}$	Wavelength and speed change across a boundary; **frequency stays constant**.	Refraction: frequency unchanged; wavelength and speed change.
$\sin\theta_c = \frac{n_2}{n_1} \quad (n_1 > n_2)$	θ_c: critical angle (denser to rarer medium)	Refracted ray grazes the boundary; above θ_c -> total internal reflection.
$\frac{1}{f} = \frac{1}{x_i} + \frac{1}{x_o}$ $m = \frac{h_i}{h_o} = -\frac{x_i}{x_o}$	f: focal length ($f > 0$ convex; $f < 0$ concave) x_o: object distance (always +) x_i: image distance ($x_i > 0$ real; $x_i < 0$ virtual) m: magnification	Thin lens equation and image size/orientation.
$\lambda = \frac{xd}{L}$ $m\lambda = \frac{x_m d}{L}$	λ: wavelength (m) x, x_m: fringe spacing on screen (m) d: slit separation (m) L: slit-to-screen distance (m) $m = 0, 1, 2, \ldots$: order number	Young's double-slit bright fringes; need $L \gg d$.
$2x_1 = \frac{2\lambda L}{w}$	x_1: center to first dark fringe w: slit width L: slit-to-screen distance	Width of **central bright band** (single-slit diffraction).

$m\lambda = d \sin\theta$	$m = 1, 2, 3, \ldots$: order d: grating line spacing θ: angle from central maximum	Diffraction grating bright lines.
$v_{\frac{a}{b}} + v_{\frac{b}{c}} = v_{\frac{a}{c}}$	Subscripts: velocity of **a** relative to **b** Same line: add if same direction, subtract if opposite	Relative velocity (1D); use components in 2D.

Sign Conventions - Lenses (Haykal LO 10)

Lens / case	Sign rule and image type
Convex (converging)	$f > 0$. Real image: $x_i > 0$ (opposite side from object). Virtual image: $x_i < 0$ (same side as object).
Concave (diverging)	$f < 0$. Image always virtual: $x_i < 0$, upright, reduced.
Magnification m	$\lvert m \rvert < 1$ -> diminished; $\lvert m \rvert > 1$ -> enlarged; negative m -> inverted.
Object at focus ($x_o = f$)	Refracted rays parallel; no sharp image on a screen.

Physics Concepts Summary

Simple-language review of all 25 Haykal learning outcomes.

1. Refraction & Ray Diagrams (LO 1-2)

- Light **bends** when it crosses from one medium to another because its **speed changes**.
- Draw rays with angles measured from the **normal**.
- In a denser medium (larger n), light bends **toward** the normal when entering.
- Wavelength and speed change; **frequency does not**.

2. Snell's Law & Index of Refraction (LO 3-4)

- $n_1 \sin\theta_1 = n_2 \sin\theta_2$
- Air is usually $n = 1.00$. Larger n means slower light in that medium.
- Use $n = \frac{c}{v}$ to find refractive index from wave speed.

3. Critical Angle & Total Internal Reflection (LO 5-6)

- Light from **higher** n to **lower** n bends **away** from the normal.
- At the **critical angle**, the refracted ray is along the surface.
- For incidence **greater** than θ_c: **total internal reflection** (fiber optics, sparkling water).

4. Lenses - Parts & Ray Tracing (LO 7-9)

- **Convex:** thicker center, $f > 0$, converges rays. **Concave:** thinner center, $f < 0$, diverges rays.
- **Principal axis**, focal points F, focal length f, points $2F$.
- Convex rays: parallel -> through F; through F -> parallel; through center -> straight.
- Concave: parallel in -> bends as if from virtual F on object side; always virtual, upright, reduced image.
- Convex object between F and $2F$ -> real, inverted, **magnified** beyond $2F$. Inside F -> virtual magnifier.

5. Thin Lens Equation (LO 10)

- $\frac{1}{f} = \frac{1}{x_i} + \frac{1}{x_o}$ and $m = -\frac{x_i}{x_o}$ for image height.
- Object at F on a convex lens -> refracted rays parallel; no sharp image on a screen.

6. Coherent Light & Double Slit (LO 11-15)

- **Coherent:** one wavelength (monochromatic), waves **in phase** or fixed phase, beam in one direction (laser).
- **Incoherent: multiple wavelengths** (colors), **random/out of phase**, spreads in **all directions** (bulb) -> no stable fringes.
- Monochromatic **coherent** light through two slits -> bright and dark interference fringes.
- **Constructive interference:** path difference = $m\lambda$ ($m = 0, 1, 2, \ldots$).
- Central bright fringe: $m = 0$. First-order bright fringe beside center: $m = 1$.
- Fringe spacing: $x = \lambda\frac{L}{d}$ - increases if L increases or d decreases.
- Mixing unlike sources (e.g. green + red) -> incoherent -> no stable fringe pattern.

7. Thin-Film Interference (LO 16)

- Light reflects from the top and bottom of a thin film; reflected waves interfere.
- Colors on oil or soap bubbles: thickness varies -> different wavelengths reflect strongly.
- Phase change on reflection when light enters a higher index of refraction.

8. Diffraction & Single Slit (LO 17-18)

- **Diffraction:** bending of waves around edges or through narrow slits.
- Single slit -> one wide central bright band and weaker side bands.
- Red light -> wider central band than green ($2x_1 \propto \lambda$).

9. Compare Double Slit vs Single Slit (LO 19)

- Double slit: many bright fringes of similar spacing (if coherent).
- Single slit: one dominant central maximum; side maxima are dimmer.

10. Diffraction Gratings (LO 20-22)

- Many parallel slits -> sharp, bright maxima ($m\lambda = d\sin\theta$).
- **Transmission grating:** light passes through ruled slits.
- **Reflection grating:** e.g. CD/DVD - light reflects from closely spaced tracks.
- Spectroscopes separate wavelengths (gems, astronomy).

11. Frames of Reference & Relative Velocity (LO 23-25)

- Motion depends on the chosen **frame of reference**.
- One dimension: $v_{\frac{a}{c}} = v_{\frac{a}{b}} + v_{\frac{b}{c}}$ - add if same direction, subtract if opposite.
- Two dimensions: add velocity **vectors** by components (boat on river, plane in wind).

Topic 1: Refraction of Light

Textbook reference: pages 90-96 - Inspire Physics Grade 10 Advanced

Key Idea

When light crosses a boundary between two media it **refracts** (bends). The **normal** is perpendicular to the surface. Measure θ_1 and θ_2 from the normal. Frequency stays constant; wavelength and speed change.

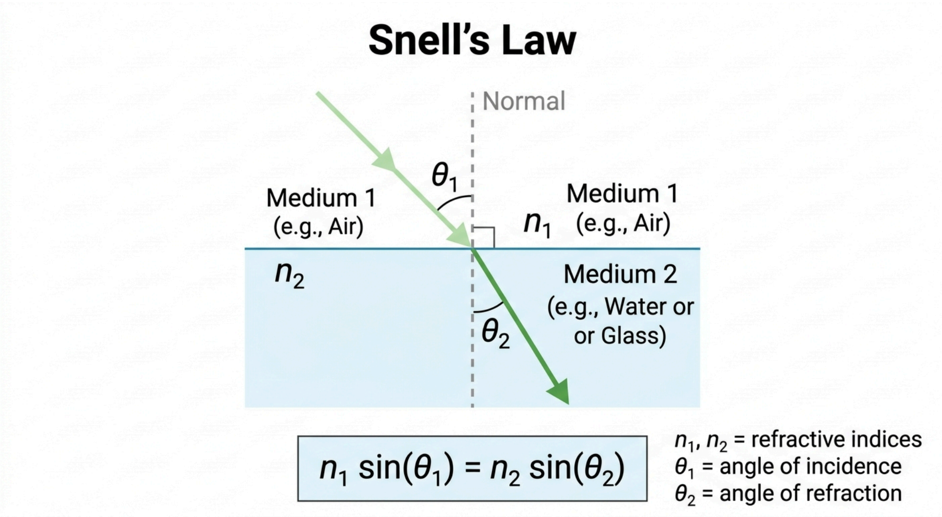


Figure 18-19: Refraction at a boundary (textbook p. 90-91). Labels on the diagram match Snell's law: n_1, θ_1 in the upper medium; n_2, θ_2 in the lower medium; angles measured from the normal (dashed line).

Snell's Law and Index of Refraction

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

What each symbol means

- n_1, n_2 - refractive index of medium 1 and medium 2 (no unit; air $\approx$ 1.00)
- θ_1 - angle of **incidence** (between incident ray and the **normal**), in degrees or radians
- θ_2 - angle of **refraction** (between refracted ray and the normal)

$$n = \frac{c}{v}$$

What each symbol means

- n - refractive index of the medium
- $c \approx 3.00 \times 10^8 \text{ m/s}$ - speed of light in vacuum
- v - speed of light in that medium (m/s)

How to read the figure: The **incident** ray travels in medium 1 and strikes the boundary at angle θ_1 from the normal. The **refracted** ray continues in medium 2 at angle θ_2. In the diagram, $n_2 > n_1$ (e.g. air to water/glass), so the refracted ray bends **toward** the normal ($\theta_2 < \theta_1$).

Rules: Light entering a **higher** n bends **toward** the normal. Light entering a **lower** n bends **away** from the normal.

Critical Angle and Total Internal Reflection

$$\sin\theta_c = \frac{n_2}{n_1} \quad (n_1 > n_2)$$

What each symbol means

- θ_c - critical angle (in the **denser** medium, n_1)
- n_1 - refractive index of the denser medium (where the ray starts)
- n_2 - refractive index of the rarer medium (e.g. air)
- Used when light goes from higher n to lower n; if $\theta_1 > \theta_c$ -> total internal reflection

Practice Questions

Q1

When light crosses from air into glass, which quantity does **not** change?

A. Frequency
B. Wavelength
C. Speed
D. Direction of travel

Answer / Solution:

A. Frequency is fixed by the source. Wavelength and speed change in the new medium (LO 2).

Q2

Light travels from air ($n = 1.00$) into water ($n = 1.33$). The refracted ray bends:

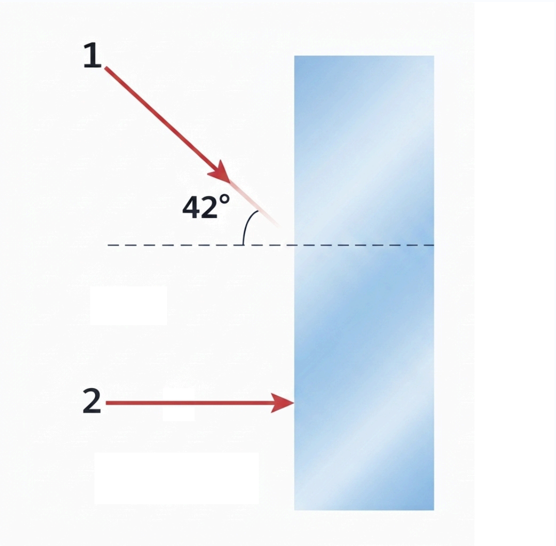
A. Toward the normal
B. Away from the normal
C. Along the surface only
D. Not at all

Answer / Solution:

A. Into higher n, the ray bends toward the normal.

Q3 Past MOE

Ray 1 enters glass from air ($n_{\text{air}} = 1.00$) at incidence 42.0 deg. If $n_{\text{glass}} = 1.52$, what is the angle of refraction θ_2 inside the glass?



A.26.1 deg
B.31.8 deg
C.42.0 deg
D.48.0 deg

Answer / Solution:

$1.00 \sin 42.0 \text{ deg} = 1.52 \sin \theta_2$
$\sin \theta_2 = \frac{\sin(42.0 \text{ deg})}{1.52} \approx 0.440$ -> $\theta_2 \approx 26.1$ deg (A). Practice Prob. 30 style.

Q4 Textbook

A laser in air enters ethanol at incidence 37.0 deg. If $n_{\text{ethanol}} = 1.36$, find θ_2. (Practice Prob. 30, p. 92)

Answer / Solution:

$\sin\theta_2 = \left(\frac{1.00}{1.36}\right)\sin 37.0\,\text{deg} = 0.441$ -> $\theta_2 \approx 26.1\,\text{deg}$.

Q5 Textbook

Light goes from air into water; the angle of refraction is 25.0 deg. Find the angle of incidence. ($n_{\text{water}} = 1.33$) (Practice Prob. 31)

Answer / Solution:

$1.00\sin\theta_1 = 1.33\sin 25.0\,\text{deg}$ -> $\theta_1 = \sin^{-1}(1.33 \times 0.4226) \approx 34.2\,\text{deg}$.

Q6 **Textbook**

Diamond facet: light in air hits diamond at 45.0 deg. Find θ_2 if $n_{\text{diamond}} = 2.42$. (Practice Prob. 32)

Answer / Solution:

$\sin\theta_2 = \sin 45.0\frac{\text{deg}}{2.42} = 0.293$ -> $\theta_2 \approx 17.0\,\text{deg}$.

Q7 **Textbook**

Unknown block in water: incidence in water is 31 deg, refraction in block is 27 deg. Find n_{block}. ($n_{\text{water}} = 1.33$) (Practice Prob. 33)

Answer / Solution:

$1.33 \sin 31\,\text{deg} = n \sin 27\,\text{deg}$ -> $n = 1.33 \times \frac{0.515}{0.454} \approx 1.51$.

Q8 Textbook

Calculate the speed of light in flint glass ($n = 1.62$). (Check Your Progress 38, p. 96)

Answer / Solution:

$v = \frac{c}{n} = 3.00 \times \frac{10^8}{1.62} = 1.85 \times 10^8 \quad \text{m/s}.$

Q9 Past MOE

A ray in glass ($n = 1.5$) strikes the glass-air boundary at 45.0 deg incidence.

A. It refracts into air at about 72 deg

B. Critical angle is about 41.8 deg; at 45 deg total internal reflection occurs

C. It passes straight through unchanged

D. Critical angle is 90 deg

Answer / Solution:

$\sin\theta_c = \frac{n_2}{n_1} = \frac{1.0}{1.5} = 0.667$ -> $\theta_c \approx 41.8 \text{ deg}$. Since $45 \text{ deg} > \theta_c$, **total internal reflection** (B).

Q10 Past MOE

(a) Find the critical angle for glass ($n = 1.5$) to air ($n = 1.0$).

(b) What happens for incidence **greater** than the critical angle?

Answer / Solution:

(a) $\theta_c = \sin^{-1}\left(\frac{1.0}{1.5}\right) \approx 41.8\,\text{deg}$.

(b) **Total internal reflection** - no refracted ray into air; all light reflects back into glass.

Q11 Textbook

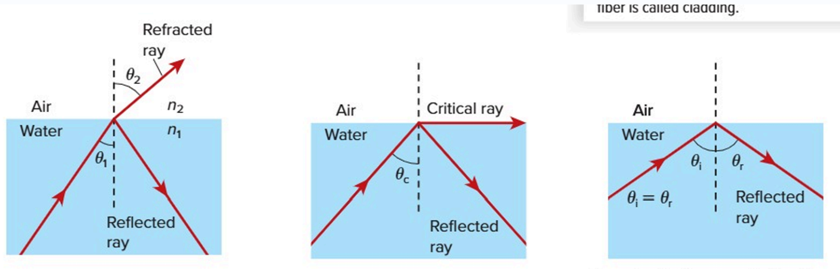
Light in water ($n = 1.33$) hits the water-air surface at $50.0\,\text{deg}$. Does it refract or reflect? (Check Your Progress 36-37 style)

Answer / Solution:

$\theta_c = \sin^{-1}\left(\frac{1.00}{1.33}\right) \approx 48.8\,\text{deg}$. $50\,\text{deg} > \theta_c$ -> total internal reflection.

Q12 Textbook

When light travels from water (n_1) into air (n_2), which statement correctly describes the behavior of the ray for angle of incidence θ_1? (Textbook Figure 21)



At an angle of incidence less than the critical angle, light is partially refracted and partially reflected.

A ray refracted along the boundary of the medium forms the critical angle.

An angle of incidence greater than the critical angle results in total internal reflection, which follows the law of reflection.

Figure 21 Refraction and reflection of light traveling between mediums depend on the angle of incidence θ_1.

A. For $\theta_1 < \theta_c$, the ray is entirely refracted into air and no light reflects at the boundary
B. For $\theta_1 = \theta_c$, the refracted ray travels along the boundary ($\theta_2 = 90\,\text{deg}$ relative to the normal)
C. For $\theta_1 > \theta_c$, the ray is partially refracted into air and partially reflected into the water
D. Total internal reflection occurs whenever light goes from lower n to higher n

Answer / Solution:

B. At the critical angle the refracted ray grazes the surface.
Why not A: Some reflection usually occurs below θ_c.
Why not C: For $\theta_1 > \theta_c$ (denser to rarer), you get **total** internal reflection, not partial refraction.
Why not D: TIR requires light traveling from **higher** n to **lower** n.

Q13 **Textbook**

A beam in air has incidence 57.5 deg on glass ($n = 1.52$). The angle of refraction is closest to:

A.32.5 deg
B.57.5 deg
C.90 deg
D.22 deg

Answer / Solution:

$1.00 \sin 57.5 \text{ deg} = 1.52 \sin \theta_2$
$\sin \theta_2 = \frac{\sin(57.5 \text{ deg})}{1.52} \approx \frac{0.844}{1.52} \approx 0.555$
$\theta_2 = \sin^{-1}(0.555) \approx 33.7 \text{ deg}$ -> closest **A. 32.5 deg** (Check Your Progress 37).

Q14

Dispersion occurs because:

A. The index of refraction depends on wavelength
B. Frequency changes in glass
C. Light has no wave nature
D. Snell's law does not apply to lenses

Answer / Solution:

A. Violet has higher n than red in most media, so colors separate.

Q15 Textbook

Challenge (Practice 34): Light in air: $\theta_1 = 45.0$ deg, $\theta_2 = 27.7$ deg in unknown medium. Find n.

Answer / Solution:

$n = \sin 45.0 \frac{\text{deg}}{\sin} 27.7 \text{ deg} = \frac{0.707}{0.465} \approx 1.52$ (float glass).

Extra practice (Haykal LO 3-4, proportional reasoning)

Q16 Textbook

Light in air ($n_1 = 1.00$) enters glass ($n_2 = 1.50$) at $\theta_1 = 30.0$ deg . Find θ_2 closest to:

A.19.5 deg

B.30.0 deg

C.48.6 deg

D.90.0 deg

Answer / Solution:

$\sin \theta_2 = \sin 30.0 \frac{\text{deg}}{1.50} = \frac{0.500}{1.50} = 0.333$ -> $\theta_2 \approx 19.5$ deg (A). Practice Prob. 30 style.

Q17

In Snell's law, if θ_1 is fixed and n_2 is **doubled** , $\sin \theta_2$ becomes:

A. Doubled

B. Halved

C. Unchanged

D. Zero always

Answer / Solution:

B. From $n_1 \sin \theta_1 = n_2 \sin \theta_2$, $\sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2}$ - if n_2 doubles, $\sin \theta_2$ is halved (so θ_2 decreases).

Q18

If the speed of light in a material is **halved** (v becomes $\frac{v}{2}$), the index of refraction $n = \frac{c}{v}$:

A. Halves
B. Doubles
C. Stays the same
D. Becomes zero

Answer / Solution:

B. $n \propto \frac{1}{v}$ - slower light means larger n.

Q19 Textbook

Flint glass: $n = 1.62$. (a) Find speed of light in the glass. (b) If v were half this value, what would n become? (Check Your Progress 38 extension)

Answer / Solution:

(a) $v = \frac{c}{n} = 3.00 \times \frac{10^8}{1.62} = 1.85 \times 10^8 \quad \text{m/s}$.

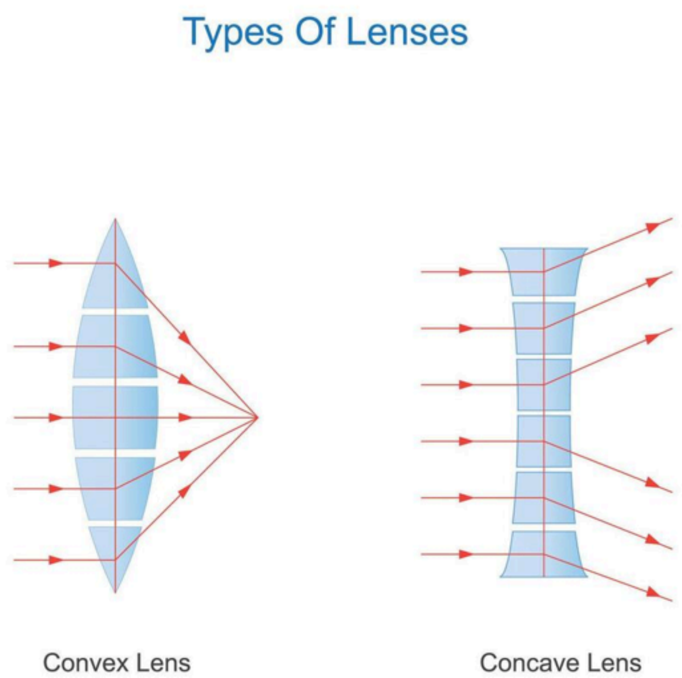
(b) Half speed -> n doubles to ≈ 3.24 (since $n = \frac{c}{v}$).

Topic 2: Convex and Concave Lenses

Textbook reference: pages 98-106 - Inspire Physics Grade 10 Advanced

Key Idea

Convex (converging): thicker at center; brings parallel rays toward focal point F; $f > 0$.
Concave (diverging): thinner at center; spreads parallel rays as if from a virtual focus; $f < 0$.
For ray diagrams, trace **three principal rays** (see tables below). For calculations: $\frac{1}{f} = \frac{1}{x_i} + \frac{1}{x_o}$, $m = -\frac{x_i}{x_o}$.



Convex and concave lenses (textbook Fig. 27, p. 97)

Convex vs concave at a glance

Feature	Convex (converging)	Concave (diverging)
Shape	Thicker at center	Thinner at center
Effect on parallel rays	Meet at real focus F on far side	Diverge; appear to come from virtual F on near side
Sign of f	$f > 0$	$f < 0$
Typical images	Real or virtual depending on x_o	Always virtual, upright, reduced

Common uses	Camera, projector, magnifier (object inside f)	Eyeglasses for nearsightedness, peepholes

Three principal rays (for ray diagrams)

Incoming ray	Convex lens	Concave lens
Parallel to axis	Refracts through F on image side	Refracts so extension passes through virtual F on object side
Through optical center	Passes straight through (no bend)	Passes straight through
Through F on object side	Emerges parallel to axis	Aimed at virtual F on object side; emerges parallel

Tip: Where refracted rays (or their backward extensions) cross, draw the image arrow. Real images: rays actually meet. Virtual images: extensions meet on the **object** side of the lens.

Convex lens - image vs object position

Object position (convex)	Image location	Characteristics
$x_o > 2f$	Between f and $2f$ on image side	Real, inverted, reduced
$x_o = 2f$	At $2f$	Real, inverted, same size
$f < x_o < 2f$	Beyond $2f$	Real, inverted, magnified
$x_o = f$	No image on screen	Rays parallel after lens
$x_o < f$	Same side as object	Virtual, upright, magnified

Concave lens - any object position

Object position (concave)	Image location	Characteristics
Any $x_o > 0$	Between lens and object (same side as object)	Always **virtual**, **upright**, **reduced**; $\lvert m\rvert < 1$

Magnification quick check: $|m| < 1$ -> diminished; $|m| > 1$ -> enlarged; $m < 0$ -> inverted; $m > 0$ -> upright.

Thin lens equations (LO 10)

$$\frac{1}{f} = \frac{1}{x_i} + \frac{1}{x_o}$$

What each symbol means

- f - focal length (m); $f > 0$ convex, $f < 0$ concave
- x_o - object distance from lens (always positive in textbook sign convention)
- x_i - image distance; $x_i > 0$ real image (opposite side), $x_i < 0$ virtual (same side as object)

$$m = \frac{h_i}{h_o} = -\frac{x_i}{x_o}$$

What each symbol means

- m - magnification (no unit)
- h_o, h_i - object and image heights
- $|m| > 1$ enlarged; $|m| < 1$ reduced; $m < 0$ inverted; $m > 0$ upright

Practice Questions

Q15

The focal length of a concave lens is always:

A. Positive
B. Negative
C. Zero
D. Equal to object distance

Answer / Solution:

B. Diverging lens: focal point on object side; $f < 0$ in equations.

Q16

A convex lens used as a simple magnifier requires the object:

A. Beyond $2f$
B. At $2f$
C. Between f and the lens
D. At f

Answer / Solution:

C. Object inside focal length gives virtual, upright, enlarged image (LO 9).

Q31 Textbook

An object is placed at $x_o > 2f$ from a convex lens (Textbook Figure 28). Which statement is correct?

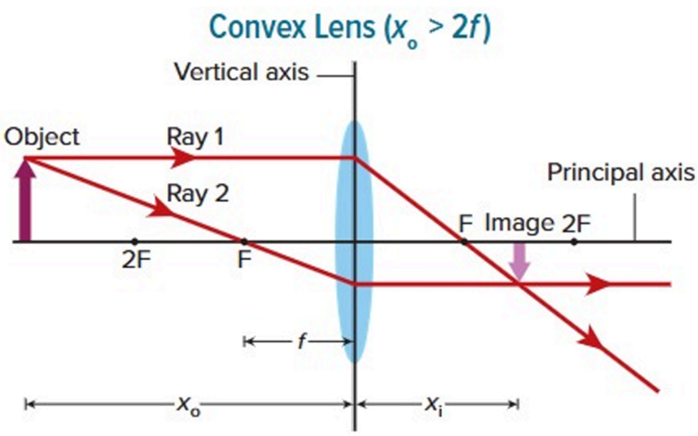


Figure 28 An object placed at a distance greater than twice the focal length from the lens will produce an image that is real, reduced in size, and inverted.

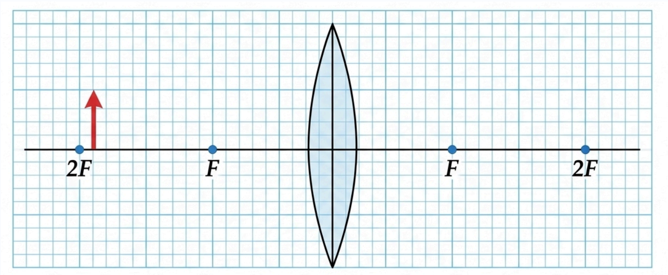
A. Ray 1 is parallel to the axis and refracts through F; ray 2 passes through F and emerges parallel; they form a real, inverted, reduced image between f and $2f$
B. The rays diverge after the lens, forming a virtual, upright, magnified image on the same side as the object
C. The rays converge at F; the image is the same size as the object
D. The rays form a real, inverted image with $x_i > 2f$

Answer / Solution:

A. Standard ray tracing for $x_o > 2f$: image between f and $2f$, real, inverted, smaller.
B: Diverging rays -> concave lens or object inside f.
C: Object would need to be at F.
D: For $x_o > 2f$, the image lies **between** f and $2f$, not beyond $2f$.

Q17 Past MOE

An object is placed between F and $2F$ in front of a converging lens. By ray tracing, the image is:



A. Real, inverted, diminished, between F and $2F$

B. Real, inverted, magnified, beyond $2F$

C. Virtual, upright, magnified, same side as object

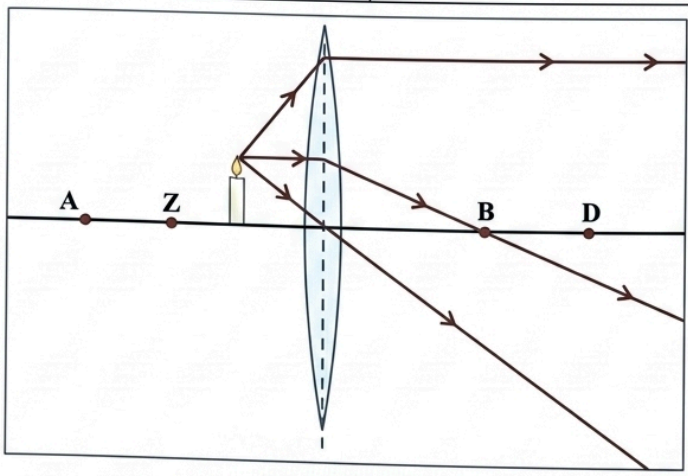
D. Real, inverted, exactly at $2F$

Answer / Solution:

B. Rays converge beyond $2F$; image is real, inverted, and larger (Past MOE).

Q18 Past MOE

QUESTION 6	6	السؤال ٦
An object placed in front of a convex lens as shown in the figure.		وضع جسم أمام عدسة محدبة كما في الشكل.



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A- Complete the ray diagram and draw the formed image on the figure.

- أكمل مخطط الأشعة على الشكل وارسم الصورة التكوّنة.

B- In which position (A,B,D,Z) will the image form?

- في أي موقع (A,B,D,Z) ستتكون الصورة؟

....

C- What are the characteristics of the formed image of the object?

- ما صفات الصورة التكونة للجسم؟

....

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Answer / Solution:

Part A - Ray diagram and image

Trace three principal rays from the top of the candle:

- Parallel ray -> refracts through F on the image side (point B).
- Ray through F on the object side (point Z) -> emerges parallel to the axis.
- Ray through the optical center -> straight line, no bending.

Rays cross beyond $2F$ on the image side. Draw an **inverted** image arrow at the intersection.

Part B - Where is the image?

Answer: D. Point B is the focal point on the image side. The object is between F and $2F$ on the left, so the real image forms beyond $2F$ where the rays meet (position D).

Part C - Characteristics

- **Real** (rays actually converge; can be projected on a screen)
- **Inverted** (image below the principal axis)
- **Magnified** (image taller than the object)

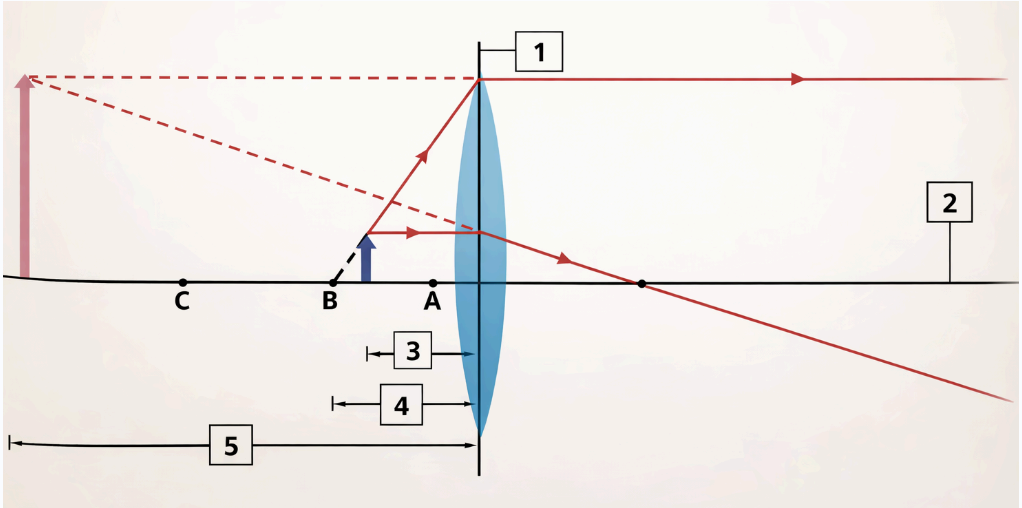
Q19 Past MOE

Use the ray diagram below (labels 1-5).

(a) Match each label to: principal axis, principal plane, focal length, object distance, image distance.

(b) State three characteristics of the image shown.

(c) What happens if the object is placed at the focus? Explain.



Answer / Solution:

(a) Principal axis -> 2; principal plane -> 1; focal length -> 4; object distance -> 3; image distance -> 5.

(b) Virtual, upright, magnified (object inside f).

(c) At F, refracted rays are parallel; no real image forms on a screen.

Q20 **Textbook**

Object 32.0 cm from convex lens, $f = 8.0$ cm, object height 3.0 cm. Find (a) x_i, (b) h_i, (c) orientation. (Example 5, p. 100-101)

Answer / Solution:

(a) $x_i = (8)\frac{32}{32-8} = 11$ cm (real).

(b) $h_i = -(11)\frac{3}{32} = -1.0$ cm.

(c) Negative height ? inverted.

Q21 **Textbook**

Practice Prob. 43: Object 25.0 cm from convex lens, $f = 10.0$ cm. Find image position and type.

Answer / Solution:

$x_i = (10)\frac{25}{25-10} = 16.7$ cm ? real, inverted (beyond f).

Q22 Textbook

Practice Prob. 44: Concave lens, $f = -15$ cm, object at 20 cm. Find x_i.

Answer / Solution:

$\frac{1}{-15} = \frac{1}{x_i} + \frac{1}{20}$? $\frac{1}{x_i} = -\frac{7}{60}$? $x_i = -8.6$ cm (virtual).

Q23 Textbook

Check Your Progress 51: Object 15 cm from lens; image real, 25 cm on opposite side. Find f.

Answer / Solution:

$\frac{1}{f} = \frac{1}{25} + \frac{1}{15} = \frac{8}{75}$? $f = 9.4$ cm.

Q24

For a concave lens, regardless of object distance, the image is always:

A. Real and inverted
B. Virtual, upright, and reduced
C. Real and magnified
D. At $2f$

Answer / Solution:

B. Table 3, p. 99-100.

Q25 Textbook

Practice Prob. 46: Convex lens $f = 12$ cm, object at 18 cm. Find magnification and state if the image is larger or smaller.

Answer / Solution:

$x_i = (12)\frac{18}{18-12} = 36$ cm; $m = -2$ -> magnified ($|m| = 2$).

Extra practice (Haykal LO 10, proportional reasoning)

Q26 Textbook

Convex lens: object at $2f$. If f is **doubled** (same object position in cm), the image distance x_i:

A. Doubles
B. Halves
C. Stays at $2f$ of the new lens
D. Becomes virtual always

Answer / Solution:

C. Object still at $2f$ for the new lens -> real image at $2f$ on the other side (same-size image rule still applies at $2f$).

Q27 Textbook

Practice Prob. 45 style: Convex lens, $f = 10.0 \text{ cm}$, object 30.0 cm from lens. Find x_i and state if real or virtual.

Answer / Solution:

$x_i = f\frac{x_o}{x_o - f} = (10)\frac{30}{30-10} = 15 \text{ cm}$ -> real, inverted ($x_i > 0$).

Q28

For a fixed convex lens, if object distance x_o is **doubled** (object moves farther away), image distance x_i generally:

A. Always doubles

B. Moves closer to f (decreases toward f)

C. Becomes zero

D. Always becomes virtual

Answer / Solution:

B. From $\frac{1}{x_i} = \frac{1}{f} - \frac{1}{x_o}$, larger x_o makes $\frac{1}{x_o}$ smaller, so $\frac{1}{x_i}$ increases but x_i moves toward f from the $2f$ case (image gets smaller and closer to f).

Q29

Concave lens $f = -20 \text{ cm}$, object at 40 cm. Find x_i and $|m|$.

Answer / Solution:

$\frac{1}{x_i} = \frac{1}{-20} - \frac{1}{40} = -\frac{3}{40}$ -> $x_i = -13.3$ cm (virtual).
$m = -\frac{x_i}{x_o} = -\frac{-13.3}{40} = +0.33$ -> upright, reduced ($|m| = 0.33$).

Q30

Object distance is **doubled** for the same concave lens. The magnitude $|m|$:

A. Doubles
B. Halves
C. Stays exactly 1
D. Becomes negative only

Answer / Solution:

B. Virtual images from concave lenses get even smaller as the object moves farther away ($|m|$ decreases).

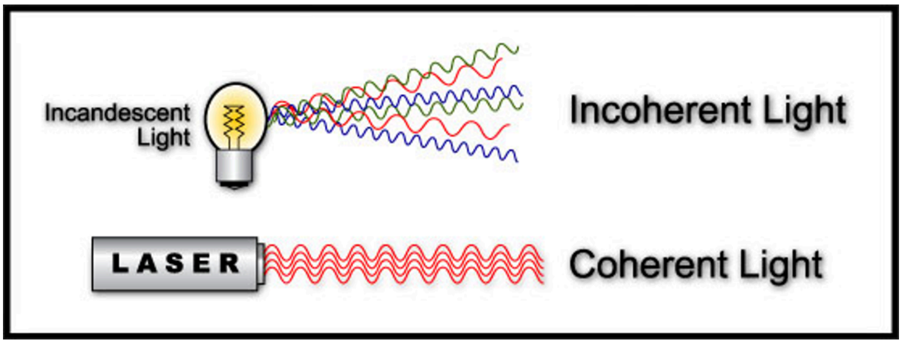
Topic 3: Interference & Thin Films

Textbook reference: pages 112-117 - Inspire Physics Grade 10 Advanced

Key Idea

Stable interference (bright and dark fringes) needs **coherent** light: waves with the **same wavelength** and a **fixed phase** relationship. **Incoherent** light cannot produce a steady fringe pattern on a screen.

Coherent vs incoherent light (LO 11)



Coherent vs incoherent light. Top: incoherent (e.g. ordinary bulb). Bottom: coherent (e.g. laser).

Property	Coherent light	Incoherent light
Wavelength / color	One wavelength (monochromatic); single color	Many wavelengths (many colors) at once
Phase	Waves stay **in phase** (peaks align) or fixed phase difference	**Random phase** - peaks and troughs do not stay aligned
Direction	Travels mainly in **one direction** (narrow beam, e.g. laser)	**Spreads in all directions** from the source (e.g. light bulb)
Example	Laser; one source split into two slits (Young's experiment)	Filament bulb; mixing red and green sources
Interference	Stable bright and dark fringes possible	No lasting fringe pattern; pattern washes out

Why double-slit needs coherence: Both slits must receive waves with the same λ and a steady phase relationship so path difference ΔL stays meaningful. Different colors or random phase -> fringes shift and blur - you do not see a clear pattern.

Exam link: Green + red sources together are **incoherent** (different λ and f) even if both are "light."

Double-slit interference

$$\lambda = \frac{xd}{L}$$

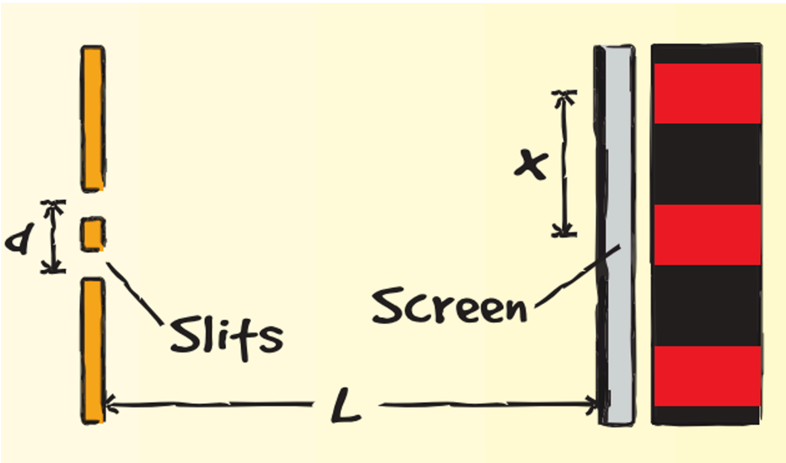
What each symbol means

- λ - wavelength of light (m)
- x - fringe spacing on the screen (distance between bright fringes, m)
- d - slit separation (distance between the two slits, m)
- L - distance from slits to screen (m); need $L \gg d$ (small-angle approximation)

$$m\lambda = \frac{x_m d}{L}$$

What each symbol means

- m - order number ($m = 0$ central bright, $m = 1$ first bright beside center, ...)
- x_m - distance from central maximum to the mth bright fringe (m)
- Constructive interference when path difference $\Delta L = m\lambda$

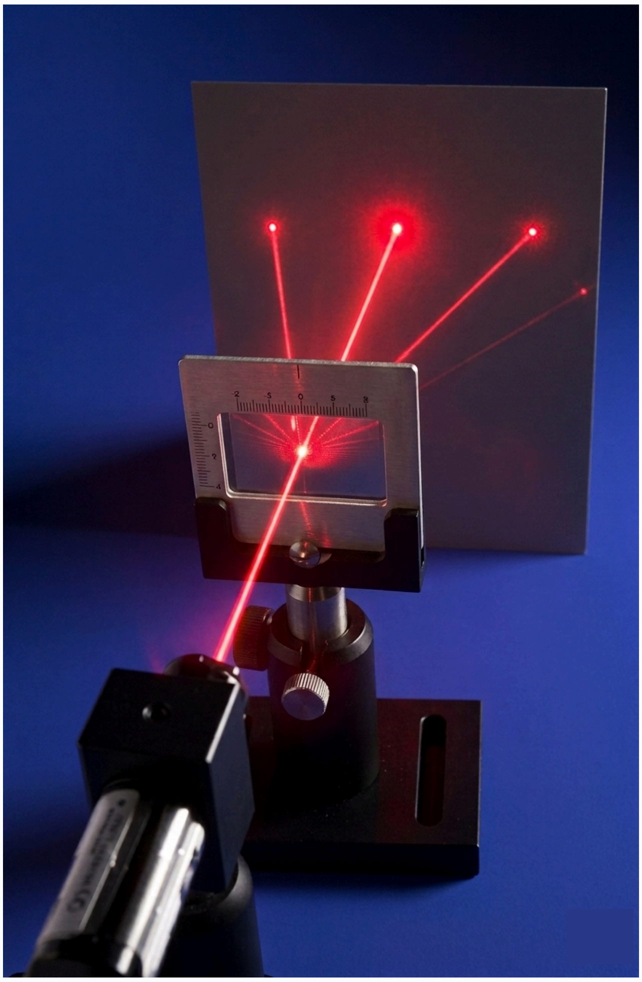


Double-slit geometry: d, L, fringe spacing x (p. 115)

Practice Questions

Q27 Past MOE

A device made of many small slits that diffracts light and forms a pattern similar to a double-slit pattern is a:



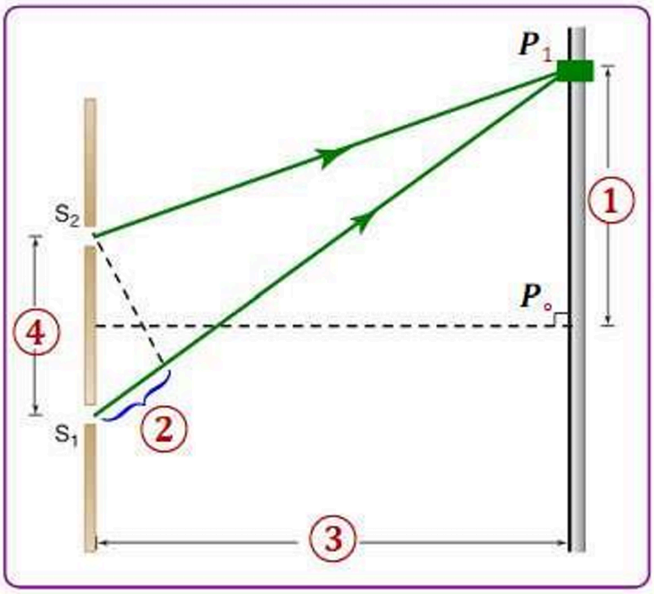
A. Diffraction grating
B. Transmitter
C. Thin-film interference setup
D. Thomas Young principle

Answer / Solution:

A. Diffraction grating (many slits). Note: full grating topic in Topic 4; this MOE item links LO 20 to prior interference ideas.

Q28 Past MOE

In Young's double-slit setup, which number indicates the distance between the slits and the screen (L)?



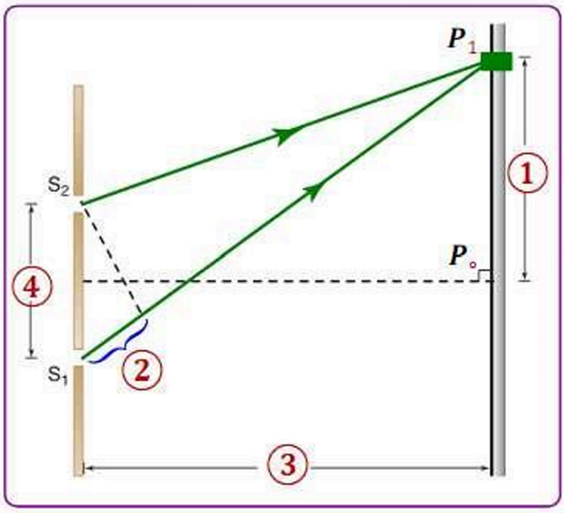
1	2
3	4

Answer / Solution:

3. Number (4) is slit separation d; (1) is fringe spacing x; (2) is path difference ΔL.

Q29

In the same diagram, number (4) represents:



A. Wavelength λ

B. Slit separation d

C. Screen distance L

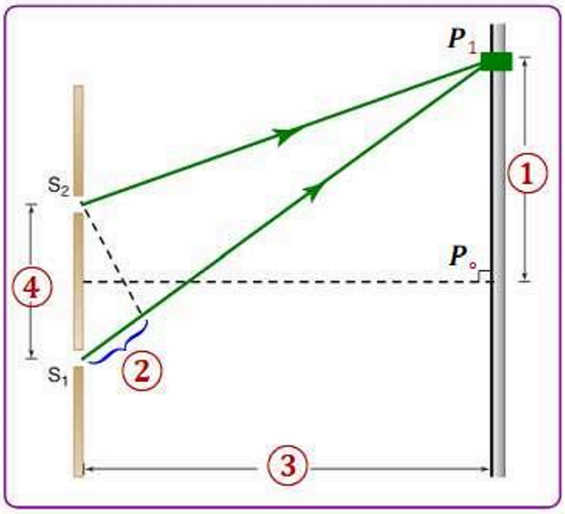
D. Path difference only

Answer / Solution:

B. Slit separation d.

Q30

If slit separation (4) increases while λ and L stay fixed, fringe spacing (1) will:



A. Increase
B. Decrease
C. Stay the same
D. Become zero instantly

Answer / Solution:

B. $x = \lambda \frac{L}{d}$? larger d ? smaller x.

Q31 Past MOE

In $\lambda = x\frac{d}{L}$, the symbol d represents:

A. Spacing between the slits
B. Distance from slits to screen
C. Spacing between bright bands on the screen
D. Wavelength of light

Answer / Solution:

A. Slit separation (Past MOE).

Q32 Past MOE

Red light forms double-slit fringes. The screen is moved farther from the slits. The fringe spacing:

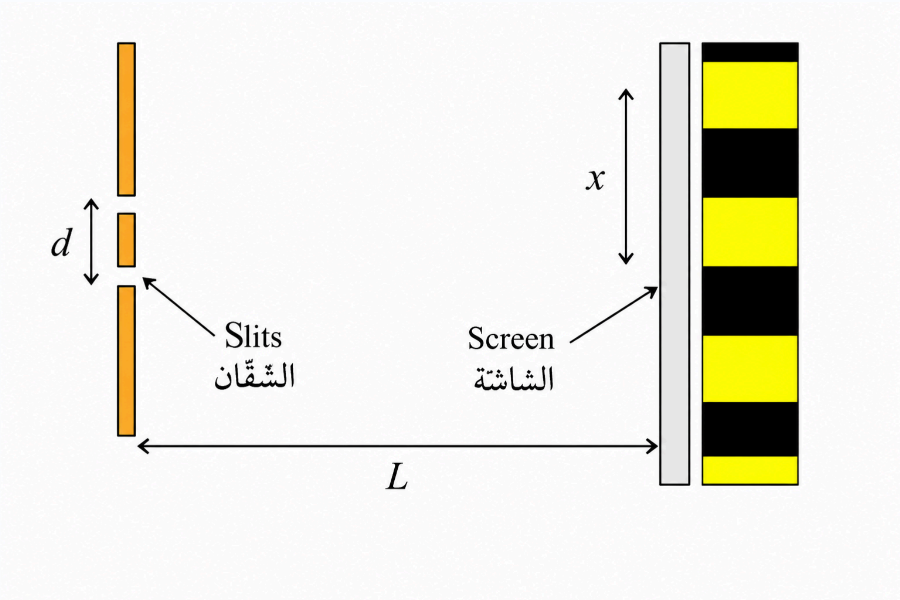
A. Increases
B. Wavelength increases
C. Wavelength decreases
D. Decreases

Answer / Solution:

A. $x \propto L$ -> fringes spread apart.

Q33 Past MOE

Sodium light $\lambda = 596$ nm, slit separation $d = 1.90 \times 10^{-5}$ m, screen $L = 0.600$ m. Find distance from central band to first-order bright band. (Practice Prob. 2 / Past MOE)

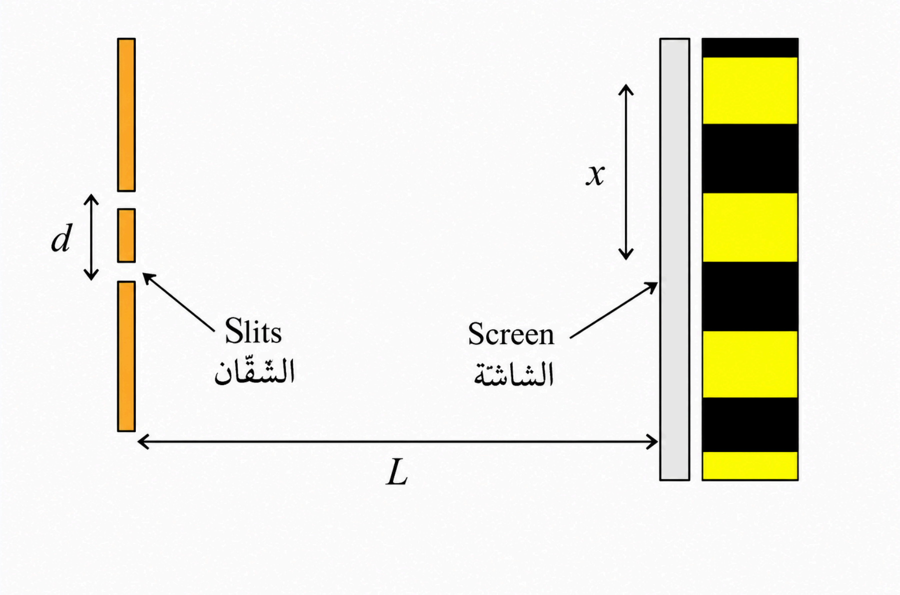


Answer / Solution:

$x = \lambda \frac{L}{d} = (5.96 \times 10^{-7}) \frac{0.600}{1.90 \times 10^{-5}} = 1.88 \times 10^{-2} \text{ m} = 1.88 \text{ cm}.$

Q34 Past MOE

Same data as Q33: (a) Calculate x to first-order band. (b) What condition must hold for d and L in $x = \lambda \frac{L}{d}$?



Answer / Solution:

(a) $x = 1.88 \text{ cm}.$

(b) $L \gg d$ (screen much farther than slit spacing) and small angle so $\sin\theta \approx \tan\theta \approx \frac{x}{L}$.

Q35 Textbook

Violet light, $d = 1.90 \times 10^{-5}\ \text{m}$, first-order bright band $13.2\ \text{mm}$ from center, $L = 0.600\ \text{m}$. Find λ. (Practice Prob. 1)

Answer / Solution:

$\lambda = x\frac{d}{L} = (0.0132)\frac{1.90\times10^{-5}}{0.600} = 4.18 \times 10^{-7}\ \text{m} = 418\ \text{nm}.$

Q36 Textbook

Laser $\lambda = 632.8\ \text{nm}$, first-order fringe $65.5\ \text{mm}$ from center, $L = 1.000\ \text{m}$. Find slit separation. (Practice Prob. 3)

Answer / Solution:

$d = x\frac{\lambda}{L}$ - use x for first order: $d = \lambda\frac{L}{x} = \left(632.8 \times 10^{-9}\right)\frac{1}{0.0655} = 9.66 \times 10^{-6}\ \text{m}.$

Q37 **Past MOE**

Two sources: green light and red light. They are most likely:

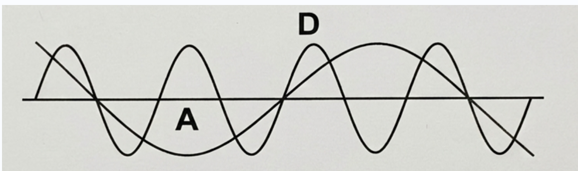
A. Coherent - both visible
B. Coherent - same speed in air
C. Incoherent - different wavelengths and frequencies
D. Incoherent - green travels faster

Answer / Solution:

C. Different f and λ -> no stable interference pattern (LO 11).

Q38 **Past MOE**

At points A and D on the wave graph, the interference is:



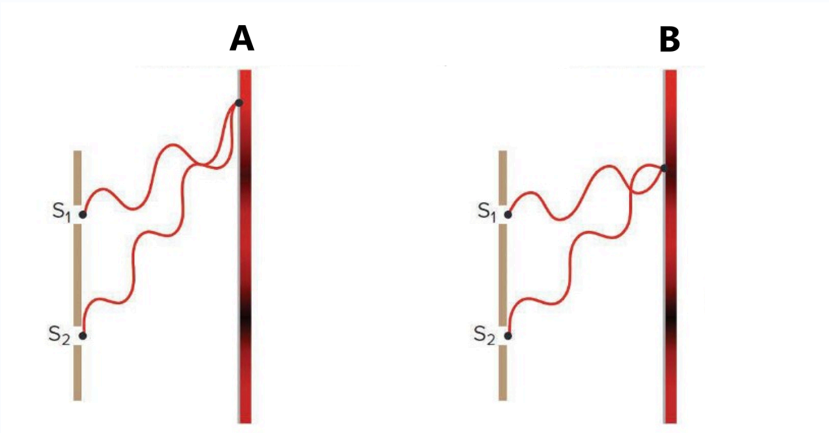
A. A: constructive, D: destructive
B. A: destructive, D: destructive
C. A: destructive, D: constructive
D. A: constructive, D: constructive

Answer / Solution:

Read graph: crest+crest or trough+trough -> constructive; crest+trough -> destructive. Match letters to diagram.

Q50 **Textbook**

Two pairs of overlapping waves are shown, labelled **A** and **B**. Which pair shows **constructive** interference and which shows **destructive** interference?



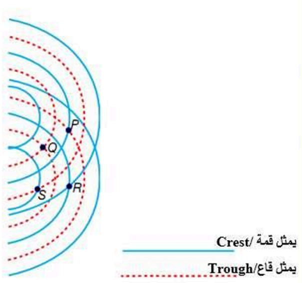
A. A: constructive; B: destructive
B. A: destructive; B: constructive
C. Both constructive
D. Both destructive

Answer / Solution:

A. **A** is constructive; **B** is destructive.

Q39 **Past MOE**

Which table row correctly describes interference at the two points in the diagram?



يوضح الرسم التخطيطي نمط التداخل الناتج عن مصدرين مترابطين لموجات الضوء.
أي صف من صفوف الجدول التالي صحيح؟

The diagram shows the pattern of interference produced by two coherent light waves sources. Which of the following table rows is correct?

	التداخل البناء Constructive interference	التدخل الهدام Destructive interference
A	S	Q
B	P	R
C	R	S
D	P	Q

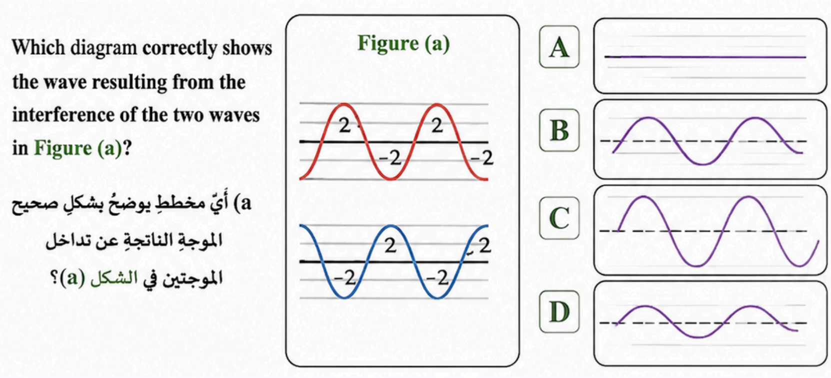
A. Row A
B. Row B
C. Row C
D. Row D

Answer / Solution:

C. Constructive: two crests or two troughs meet. Destructive: crest meets trough.

Q40 Past MOE

Red and blue waves in Figure (a) are opposite in phase. The resultant wave is shown correctly in:



A. Option A
B. Option B
C. Option C
D. Option D

Answer / Solution:

A. Equal amplitude, 180 deg out of phase -> cancel (destructive interference).

Q41 Past MOE

Sunlight on thin oil on water shows colors mainly because of:

A. Constructive and destructive interference of reflected rays in the film

B. Absorption of colors in dye in the oil

C. Refraction only inside the oil

D. Absorption by the oil film

Answer / Solution:

A. Thin-film interference (LO 16).

Q42 Past MOE

Colors on a soap bubble change as you watch mainly because:

A. Heat waves in air distort the light
B. Film thickness at a point changes over time
C. Sunlight wavelengths vary over time
D. Your vision varies

Answer / Solution:

B. Thickness changes -> different λ constructively reflect (drainage, gravity).

Q43 Textbook

Example 2 (p. 118): Oil on water, yellow-green $\lambda = 555\ \text{nm}$, $n_{\text{oil}} = 1.45$, $n_{\text{water}} = 1.33$. Minimum oil thickness for bright reflection looking straight down?

Answer / Solution:

One inversion at air-oil: $2d = \frac{\lambda}{2n_{\text{oil}}}$ -> $d = \frac{\lambda}{4n_{\text{oil}}} = \frac{555}{4\times1.45} = 95.7\ \text{nm}$.

Q44

Monochromatic coherent light through two slits produces on a screen:

A. A single bright dot only
B. Alternating bright and dark bands
C. A continuous rainbow without bands
D. No pattern

Answer / Solution:

B. Interference fringes (LO 12).

Q45

Coherent light is produced in the textbook double-slit investigation by:

A. Using two different colored lasers
B. Passing monochromatic light through two slits from one source
C. White light without filters
D. Two flashlights

Answer / Solution:

B. Single source -> fixed phase relationship (LO 11).

Extra practice (Haykal LO 13-15, proportional reasoning)

Q46 Textbook

In $\lambda = x\frac{d}{L}$, if screen distance L is **doubled** (λ and d fixed), fringe spacing x:

A. Doubles
B. Halves
C. Unchanged
D. Becomes zero

Answer / Solution:

A. $x \propto L$ - fringes spread farther apart on the screen.

Q47

If slit separation d is **doubled** (λ and L fixed), fringe spacing x:

A. Doubles
B. Halves
C. Quadruples
D. Unchanged

Answer / Solution:

B. $x \propto \frac{1}{d}$ - wider slits -> tighter fringe pattern.

Q48

If wavelength λ is **doubled** (same d and L), fringe spacing x:

A. Doubles
B. Halves
C. Unchanged
D. Divides by 4

Answer / Solution:

A. $x \propto \lambda$ - longer wavelength -> wider fringes.

Q49 Textbook

Practice Prob. 1 style: Violet light, $d = 1.90 \times 10^{-5}\ \text{m}$, first-order bright band $x = 13.2\ \text{mm}$ from center, $L = 0.600\ \text{m}$. Find λ.

Answer / Solution:

$\lambda = x\frac{d}{L} = (0.0132)\frac{1.90\times10^{-5}}{0.600} = 4.18 \times 10^{-7}\ \text{m} = 418\ \text{nm}$.

Topic 4: Diffraction, Gratings & Spectroscopy

Textbook reference: pages 121-126 - Inspire Physics Grade 10 Advanced

Key Idea

Diffraction: bending at edges/slits. Single slit: wide central maximum. **Grating:** many slits -> sharp lines. **Reflection grating:** CD/DVD - light reflects from closely spaced tracks.

Single-slit diffraction (LO 18)

$$2x_1 = \frac{2\lambda L}{w}$$

What each symbol means

- $2x_1$ - width of the **central bright band** on the screen (m)
- x_1 - distance from center of pattern to the **first dark fringe** (m)
- λ - wavelength of light (m)
- L - distance from slit to screen (m)
- w - width of the single slit (m)

Diffraction grating (LO 21)

$$m\lambda = d \sin\theta$$

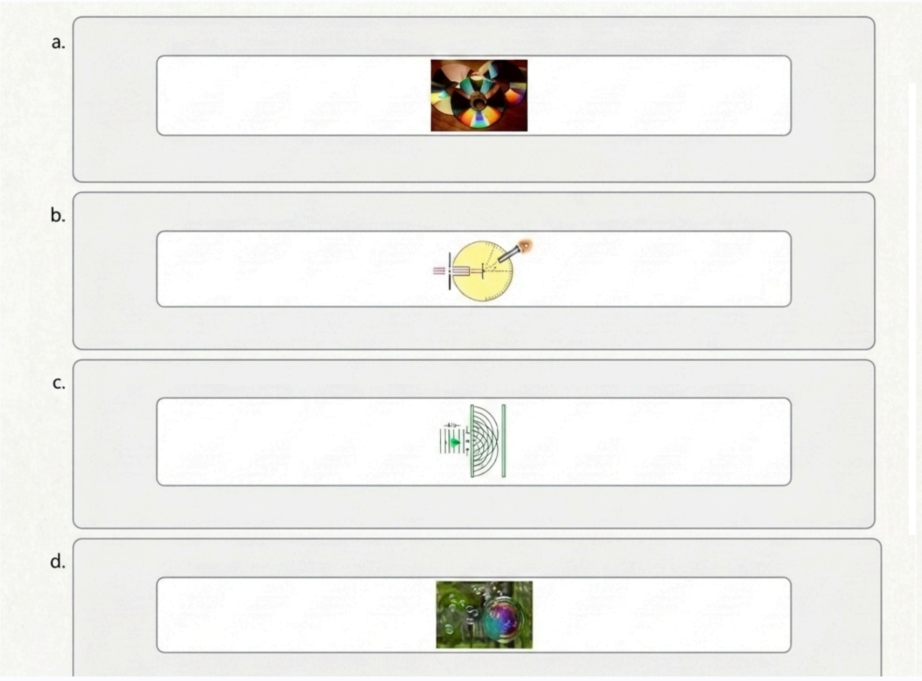
What each symbol means

- m - order of maximum ($m = 1, 2, 3, \ldots$)
- λ - wavelength (m)
- d - grating line spacing (m); e.g. $d = \frac{1}{\text{lines per metre}}$
- θ - angle from the central maximum to the bright line (measure from slit normal)

Practice Questions

Q51 Past MOE

Which is an example of a **reflection** grating?



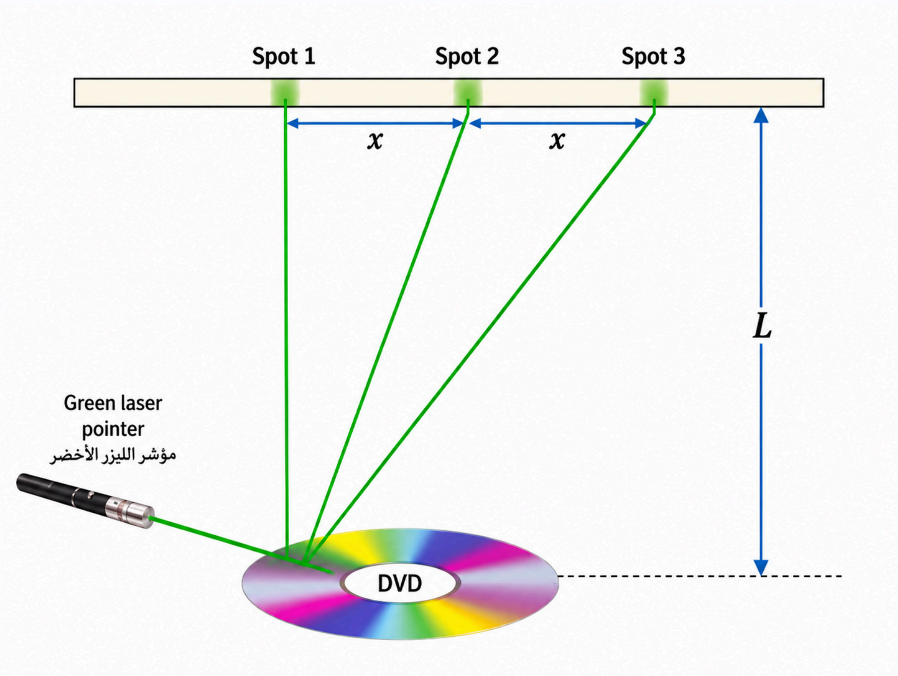
A. Compact disc (CD)
B. Prism refracting light
C. Single-slit diagram only
D. Soap bubble colors

Answer / Solution:

A. CD has closely spaced reflective tracks that diffract light. B is refraction; C is transmission diffraction; D is thin-film interference.

Q52 Past MOE

Green laser $\lambda = 532 \times 10^{-9}$ m reflects from a DVD. Adjacent bright spots on the ceiling are $x = 1.29$m apart; wall distance $L = 1.25$m. Find groove spacing d on the DVD (reflection grating, first order $m = 1$).



Answer / Solution:

$\tan\theta = \frac{x}{L} = \frac{1.29}{1.25}$ -> $\theta \approx 45.9\,\text{deg}.$
$d = \frac{\lambda}{\sin}\theta = \frac{532 \times 10^{-9}}{\sin(45.9\,\text{deg})} \approx 7.4 \times 10^{-7}$ m.

Q53

Compared with double-slit interference, single-slit diffraction has:

A. Equally bright, equally spaced fringes only
B. One wide central bright band and weaker side bands
C. No central maximum
D. Only dark bands

Answer / Solution:

B. LO 19 comparison.

Q54

Red light through the same single slit gives a central band that is ___ than green light.

A. Narrower
B. Wider
C. The same width
D. Invisible

Answer / Solution:

B. $2x_1 \propto \lambda$ - longer wavelength -> wider central band.

Q55 Textbook

Green light $\lambda = 546\ \text{nm}$, slit width $w = 0.095\ \text{mm}$, screen $L = 0.75\ \text{m}$. Find width of central bright band $2x_1$. (Practice Prob. 15)

Answer / Solution:

$2x_1 = 2\lambda\frac{L}{w} = 2(546 \times 10^{-9})\frac{0.75}{9.5\times10^{-5}} = 8.62 \times 10^{-3}\ \text{m} = 8.62\ \text{mm}.$

Q56 Textbook

Yellow $\lambda = 589$ nm, central band width 2.60×10^{-2} m, $w = 0.110$ mm. Find L. (Practice Prob. 16)

Answer / Solution:

$L = \frac{2x_1 w}{2\lambda}$
Numerator: $(2x_1)w = (0.0260)(1.10 \times 10^{-4}) = 2.86 \times 10^{-6}\ \mathrm{m}^2$
Denominator: $2\lambda = 2(5.89 \times 10^{-7}) = 1.178 \times 10^{-6}$ m
$L = \frac{2.86 \times 10^{-6}}{1.178 \times 10^{-6}} = 2.43$ m.

Q57 Textbook

He-Ne laser $\lambda = 632.8$ nm, central band $2x_1 = 15.0$ mm, $L = 1.15$ m. Find slit width. (Practice Prob. 17)

Answer / Solution:

$w = \frac{2\lambda L}{2x_1}$
$2\lambda L = 2(632.8 \times 10^{-9})(1.15) = 1.456 \times 10^{-6}\ \mathrm{m}^2$
$w = \frac{1.456 \times 10^{-6}}{0.0150} = 9.71 \times 10^{-5}$ m $\approx 97.1 \mu m$.

Q58

A diffraction grating with 10,000 lines/cm has line spacing d closest to:

$A.1.0 \times 10^{-6}$ m
$B.1.0 \times 10^{-3}$ m
$C.10$ m
$D.10^{4}$ m

Answer / Solution:

$d = \frac{1}{10000 \text{ lines/cm}} = 10^{-4}$ cm $= 1.0 \times 10^{-6}$ m (A).

Q59

A grating spectroscope separates light by:

A. Absorption in the eyepiece only
B. Different angles of constructive interference for each wavelength
C. Polarization only
D. Snell's law at one surface only

Answer / Solution:

B. $m\lambda = d \sin\theta$ - each λ peaks at different θ (LO 22).

Q60

Etching gratings on diamonds is used to:

A. Increase mass of the gem
B. Improve dispersion and brilliance of light
C. Stop all reflection
D. Measure weight only

Answer / Solution:

B. Application in textbook p. 124.

Q61

For $m = 2$, $\lambda = 500$ nm, $d = 2.0 \times 10^{-6}$ m, find θ for a transmission grating.

Answer / Solution:

$\sin\theta = m\frac{\lambda}{d} = 2\frac{500\times10^{-9}}{2.0\times10^{-6}} = 0.50$ -> $\theta = 30$ deg.

Q62

Diffraction is defined as:

A. Light slowing in glass

B. Bending of a wave as it passes the edge of a barrier

C. Complete absorption at a slit

D. Polarization by reflection

Answer / Solution:

B. LO 17.

Feature	**Double slit**	**Single slit**
Fringe spacing	Fairly uniform bright fringes	One wide central max.
Source requirement	Coherent monochromatic	Coherent monochromatic
Side maxima	Similar intensity to central region	Much dimmer than central

Extra practice (Haykal LO 18-21, proportional reasoning)

Q64

For single-slit diffraction, if λ is **doubled** (L and w fixed), central band width $2x_1$:

A. Doubles
B. Halves
C. Unchanged
D. Quadruples

Answer / Solution:

A. $2x_1 \propto \lambda$.

Q65

If slit width w is **doubled** (λ and L fixed), $2x_1$:

A. Doubles
B. Halves
C. Unchanged
D. Quadruples

Answer / Solution:

B. $2x_1 \propto \frac{1}{w}$.

Q66

If screen distance L is **doubled** (λ and w fixed), $2x_1$:

A. Doubles
B. Halves
C. Unchanged
D. Becomes zero

Answer / Solution:

A. $2x_1 \propto L$.

Q67 Textbook

Practice Prob. 18 style: Central band width $2x_1 = 2.0\ \text{ cm}$, $\lambda = 600\ \text{ nm}$, $L = 1.50\ \text{ m}$. Find slit width w.

Answer / Solution:

$w = 2\lambda \frac{L}{2x_1} = 2(600 \times 10^{-9}) \frac{1.50}{0.020} = 9.0 \times 10^{-5}\ \text{ m}.$

Topic 5: Frames of Reference & Relative Velocity

Textbook reference: pages 148-152 - Inspire Physics Grade 10 Advanced

Key Idea

Motion depends on the **frame of reference**. One dimension: add or subtract velocities along the same line. Two dimensions: add velocity **vectors** by components.

Relative velocity in 1D (LO 24)

$$v_{\frac{a}{c}} = v_{\frac{a}{b}} + v_{\frac{b}{c}}$$

What each symbol means

- $v_{\frac{a}{c}}$ - velocity of object **a** relative to frame **c** (m/s)
- $v_{\frac{a}{b}}$ - velocity of **a** relative to **b**
- $v_{\frac{b}{c}}$ - velocity of **b** relative to **c**
- Same direction: add magnitudes; opposite direction: subtract

Practice Questions

Q68

A frame of reference is:

A. Only the Earth's surface

B. The object or coordinate system from which motion is described

C. Always at rest in space

D. The speed of light only

Answer / Solution:

B. LO 23.

Q69 **Textbook**

Bus moves at 2.0 $\mathrm{m/s}$ east. You walk 4.0 $\mathrm{m/s}$ toward the front relative to the bus. Your speed relative to the street? (Practice Prob. 25)

Answer / Solution:

Same direction: $v_{\text{you/street}} = 4.0 + 2.0 = 6.0\ \mathrm{m/s}$ east.

Q70 **Textbook**

Wagon 0.75 $\mathrm{m/s}$ forward. Caterpillar crawls 2.0 $\mathrm{cm/s}$ toward rear relative to wagon. Caterpillar's velocity relative to ground? (Practice Prob. 26)

Answer / Solution:

Opposite directions: $0.75 - 0.020 = 0.73\ \mathrm{m/s}$ forward.

Q71 **Textbook**

Boat 2.5 m/s upriver relative to water. Shore sees 0.5 m/s upriver. River speed and direction? (Practice Prob. 27)

Answer / Solution:

$v_{\text{boat/shore}} = v_{\text{boat/water}} + v_{\text{water/shore}}$ -> $0.5 = 2.5 + v_{\text{w/s}}$ -> $v_{\text{w/s}} = -2.0$ m/s (river flows **downriver**, against boat).

Q72 **Textbook**

Boat 3.8 m/s east on water. Person walks 1.3 m/s south across deck. (a) Speed relative to water? (b) Direction? (Practice Prob. 28)

Answer / Solution:

(a) $v = \sqrt{3.8^2 + 1.3^2} = 4.0$ m/s.

(b) $\theta = \tan^{-1}\left(\frac{1.3}{3.8}\right) = 19$ deg south of east.

Q73 **Textbook**

Plane 150 km/h north relative to air. Wind 75 km/h east relative to ground. Plane's speed and direction relative to ground? (Practice Prob. 29)

Answer / Solution:

$v = \sqrt{150^2 + 75^2} = 168\ \text{km/h}$; $\theta = \tan^{-1}\left(\frac{75}{150}\right) = 27$ deg east of north.

Q74 **Textbook**

Check Your Progress 31: Plane 285 km/h west in air; wind 25 km/h east relative to ground. Find velocity relative to ground.

Answer / Solution:

Opposite: $285 - 25 = 260\ \text{km/h}$ west.

Q75 Textbook

Check Your Progress 33: Boat 13 $\mathrm{m/s}$ west in river flowing 5.0 $\mathrm{m/s}$ north. Velocity relative to shore (magnitude and direction).

Answer / Solution:

$v = \sqrt{13^2 + 5^2} = 13.9\ \mathrm{m/s}$; $\theta = \tan^{-1}\left(\frac{5}{13}\right) = 21$ deg north of west.

Q76 Textbook

Example 4 (p. 151): Ferry 4.0 $\mathrm{m/s}$ east. Marble rolled 0.75 $\mathrm{m/s}$ north across deck. Marble's velocity relative to water?

Answer / Solution:

$v = \sqrt{4.0^2 + 0.75^2} = 4.1\ \mathrm{m/s}$ at 11 deg north of east.

Q77

You would use **subtraction** of velocities in 1D when:

A. Two velocities are in opposite directions along the same line

B. Motion is always circular

C. Both objects are at rest

D. Only in vacuum

Answer / Solution:

A. Opposite directions -> subtract magnitudes (LO 24).

Q78 **Textbook**

Fishing boat max speed 3 m/s in still water; river 2 m/s. Maximum and minimum speed relative to shore? (Check Your Progress 32)

Answer / Solution:

Max: downstream, $3 + 2 = 5$ m/s. Min: upstream, $3 - 2 = 1$ m/s.

Q79

A moving bus can serve as a frame of reference because:

A. Only Earth is valid

B. Any object can be chosen to describe motion relative to it

C. Buses have zero velocity always

D. Relative velocity does not apply to people

Answer / Solution:

B. LO 23-24.

Topic 6: Mixed Exam-Style Review

Textbook reference: pages All Haykal LOs - Inspire Physics Grade 10 Advanced

Q80

When light enters a medium with higher n, it bends:

A. Toward the normal
B. Away from the normal
C. Not at all
D. Parallel to the surface

Answer / Solution:

A.

Q81

Total internal reflection happens when light travels from:

A. Low n to high n at any angle
B. High n to low n at incidence greater than θ_c
C. Vacuum to glass only at 0 deg
D. Air to water always

Answer / Solution:

B.

Q82

A convex lens with object at $2F$ forms an image that is:

A. Real, same size, at $2F$
B. Virtual and magnified
C. At infinity
D. Always diminished

Answer / Solution:

A.

Q83

$\lambda = x\frac{d}{L}$ requires approximately:

A. $L \ll d$
B. $L \gg d$
C. $d = 0$
D. White light only

Answer / Solution:

B. Small-angle / far-screen approximation.

Q84

First-order bright fringe in double-slit corresponds to:

A. $m = 0$
B. $m = 1$
C. $m = -1$ only for dark
D. No path difference

Answer / Solution:

B. Central is $m = 0$; first side maximum $m = 1$.

Q85

Light $n_1 = 1.00$, $\theta_1 = 40.0$ deg into plastic $n_2 = 1.49$. Find θ_2.

Answer / Solution:

$\sin\theta_2 = \sin 40\frac{\text{deg}}{1.49} = 0.431$ -> $\theta_2 = 25.5$ deg.

Q86

Double slit: $\lambda = 600 \ \text{nm}$, $d = 2.00 \times 10^{-5} \ \text{m}$, $L = 1.20 \ \text{m}$. Find fringe spacing to first order (x).

Answer / Solution:

$x = \lambda \frac{L}{d} = 3.60 \times 10^{-2} \ \text{m} = 3.60 \ \text{cm}.$

Q87

Plane $200 \ \text{km/h}$ north in air; wind from west $50 \ \text{km/h}$ (blowing east). Ground speed and direction?

Answer / Solution:

$v = \sqrt{200^2 + 50^2} = 206 \ \text{km/h}$; 14 deg east of north.

Q88

If d in $\lambda = x \frac{d}{L}$ doubles, fringe spacing x :

A. Doubles

B. Halves

C. Unchanged

D. Quadruples

Answer / Solution:

B. $x \propto \frac{1}{d}$.

Q89

If w in $2x_1 = 2\lambda\frac{L}{w}$ doubles, central band width $2x_1$:

A. Doubles
B. Halves
C. Unchanged
D. Zero

Answer / Solution:

B. $2x_1 \propto \frac{1}{w}$.

End of Revision Guide

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