



# Physics Grade 12 Advanced

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Complete Study Guide - 2025/2026

Complete Question Bank

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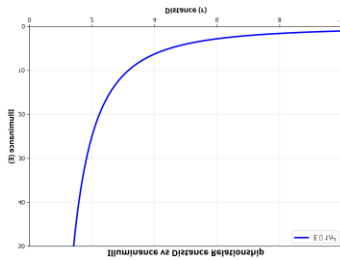
## SIMPLE EDUCATION



## Q1 • Illuminance and Distance Relationship

Page: 1

Which graph correctly shows the relationship between illuminance ( $E$ ) and distance ( $r$ )?



1

a) Linear relationship



1



b) Exponential relationship

**c) Inverse square relationship ( $E \propto 1/r^2$ )**

d) Constant relationship

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## Q2 • Luminous Flux Definition

Page: 1

What is the definition of Luminous Flux?

a) The amount of light falling on a surface

**b) The rate of light energy emitted by a source per second**

c) The brightness of a light source

d) The unit for measuring illumination

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### **Q3 • Luminous Flux Unit**

**Page: 2**

What is the unit of measurement for Luminous Flux?

a) Lux (lx)

b) Watts (W)

**c) Lumens (lm)**

d) Candela (cd)

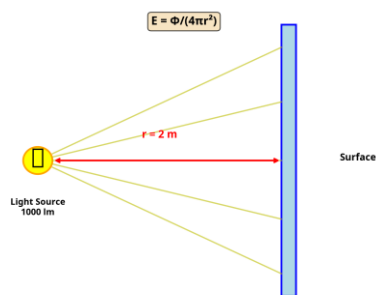
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#### Q4 • Illuminance Calculation

Page: 2

A light source emits 1000 lumens. What is the illuminance at a distance of 2 meters?



a) 19.9 lux

b) 39.8 lux

c) 79.6 lux

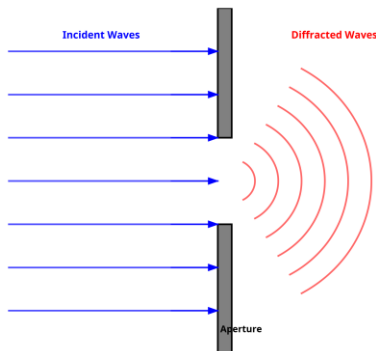
d) 159.2 lux



### Q5 • Diffraction Phenomenon

Page: 3

What is the name of the phenomenon shown in the figure where waves bend around obstacles?



a) Reflection

b) Refraction

c) Diffraction

d) Polarization

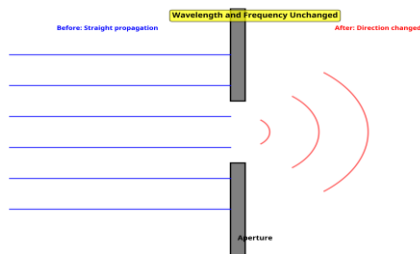
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## Q6 • Wave Properties after Diffraction

Page: 3

Which is true for waves after passing the barrier?



- a) Wavelength is increased
- b) Wavelength is decreased
- c) Direction of propagation is changed**
- d) Frequency is decreased

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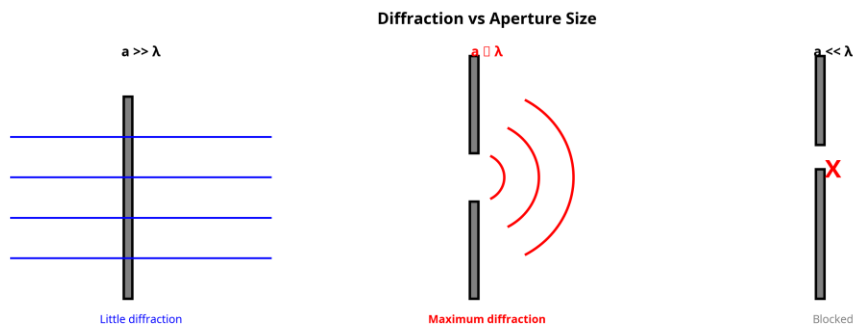
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## Q7 • Diffraction Conditions

Page: 4

When does diffraction become most noticeable?



a) When aperture is much larger than wavelength

**b) When aperture is comparable to wavelength**

c) When aperture is much smaller than wavelength

d) Diffraction is always equally noticeable

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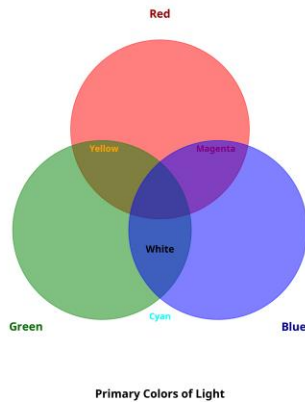
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## Q8 • Primary Colors of Light

Page: 5

What are the primary colors of light that produce white light?



- a) Red, Yellow, Blue
- b) Cyan, Magenta, Yellow

**c) Red, Green, Blue**

- d) Orange, Purple, Green

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## Q9 • Complementary Colors



**Page: 5**

Which pair of colors combines to produce white light?



a) Red + Green

**b) Yellow + Blue**

c) Cyan + Magenta

d) Blue + Green

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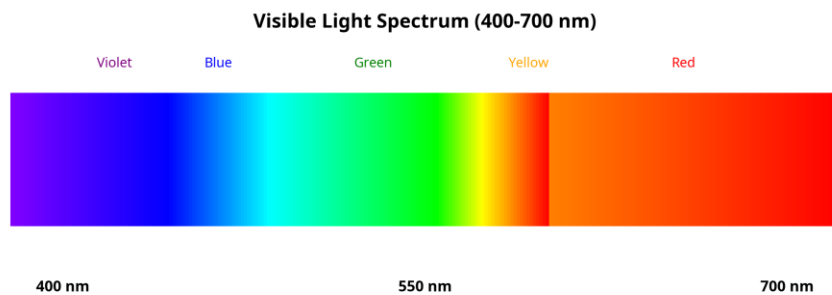
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## Q10 • Visible Light Spectrum

Page: 6

What is the approximate wavelength range of visible light?



a) 200-500 nm

**b) 400-700 nm**

c) 700-1000 nm

d) 1000-1500 nm

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## Q11 • Color Mixing

Page: 6

What color is produced when red and green light are mixed?

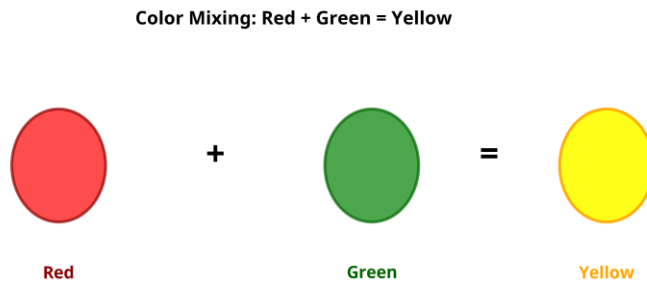
a) Blue

**b) Yellow**

c) Cyan

d) Magenta

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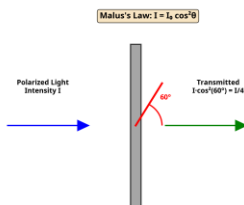




## Q12 • Malus's Law Application

Page: 7

Polarized light of intensity  $I$  passes through an analyzer at  $60^\circ$ . What is the final intensity?



- a)  $I$
- b)  $I/2$
- c)  $I/4$**
- d)  $I/8$

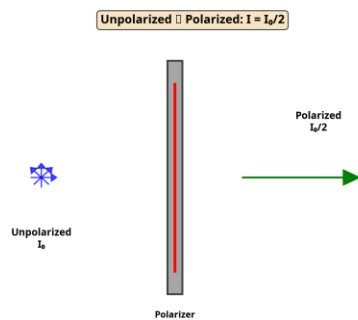
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## Q13 • Unpolarized Light



**Page: 7**

Unpolarized light of intensity  $I_0$  passes through a polarizer.  
The transmitted intensity is:



- a)  $I_0$
- b)  $I_0/2$**
- c)  $I_0/4$
- d) Zero

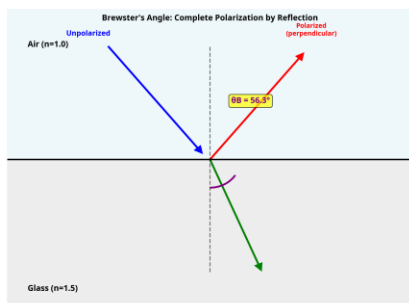
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## Q14 • Polarization by Reflection

Page: 8

At what angle does complete polarization occur by reflection (Brewster's angle for glass,  $n=1.5$ )?



a)  $45^\circ$

b)  $53.1^\circ$

c)  $56.3^\circ$

d)  $60^\circ$

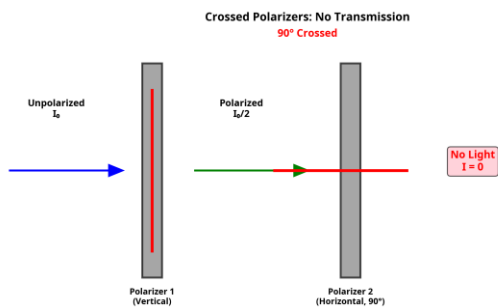
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## Q15 • Crossed Polarizers



**Page: 8**

What happens when two polarizers are crossed at  $90^\circ$ ?



- a) Maximum light transmission
- b) 50% light transmission
- c) No light transmission**
- d) 25% light transmission

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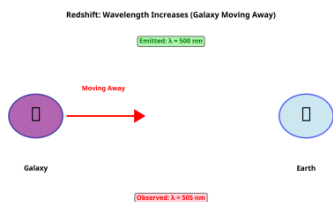
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## Q16 • Galaxy Motion - Redshift

Page: 9

A galaxy emits light at 500 nm. On Earth it's measured as 505 nm. What can be concluded?



a) Moving toward Earth

**b) Moving away from Earth (redshift)**

c) Stationary

d) Cannot determine

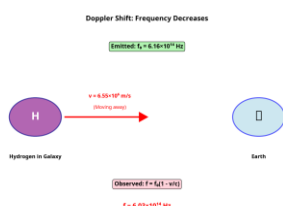
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### Q17 • Doppler Shift Calculation

Page: 9

A hydrogen atom in a galaxy moving  $6.55 \times 10^6$  m/s away from Earth emits light with frequency  $6.16 \times 10^{14}$  Hz. What frequency is observed?



a)  $6.16 \times 10^{14}$  Hz

**b)  $6.03 \times 10^{14}$  Hz**

c)  $6.29 \times 10^{14}$  Hz

d)  $5.90 \times 10^{14}$  Hz

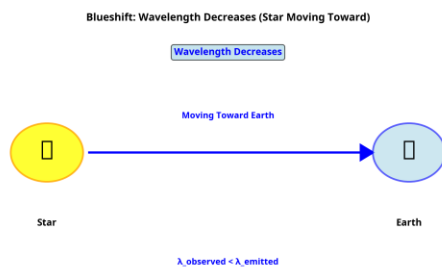
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## Q18 • Blueshift Phenomenon

Page: 10

If a star is moving toward Earth, what happens to the observed wavelength?



a) Increases (redshift)

**b) Decreases (blueshift)**

c) Stays the same

d) Becomes zero



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## Q19 • Law of Reflection

Page: 11

A light ray strikes a mirror at  $42^\circ$  to the normal. What is the angle of reflection?



a)  $21^\circ$

**b)  $42^\circ$**

c)  $48^\circ$

d)  $84^\circ$



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## Q20 • Plane Mirror Image

**Page: 11**

Which property describes a plane mirror image?

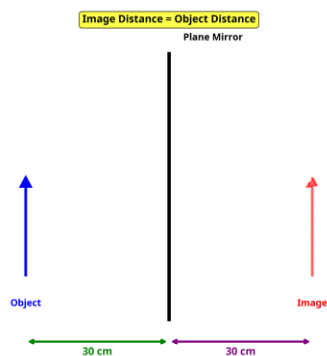
- a) Always magnified
- b) Always inverted
- c) Always virtual and erect**
- d) Can be projected on a screen

## Q21 • Mirror Image Distance



**Page: 12**

An object is placed 30 cm in front of a plane mirror. Where is the image located?



a) 15 cm behind mirror

**b) 30 cm behind mirror**

c) 60 cm behind mirror

d) At the mirror surface

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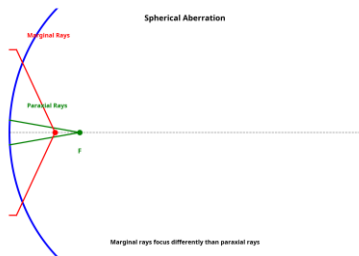
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## Q22 • Spherical Aberration Cause

Page: 13

What causes spherical aberration in concave mirrors?



a) Different colors focus at different points

**b) Marginal rays focus differently than paraxial rays**

c) Mirror absorbs too much light

d) Image becomes magnified unevenly

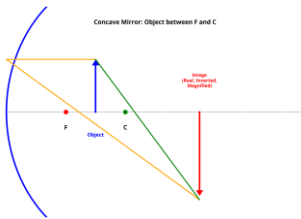
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### Q23 • Concave Mirror - Object between F and C

Page: 13

For a concave mirror, an object is placed between the focal point (F) and the center of curvature (C). Which describes the image formed?



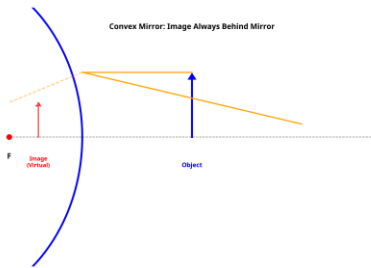
- a) Virtual, erect, and magnified
- b) Real, inverted, and diminished
- c) Real, inverted, and magnified**
- d) Virtual, erect, and diminished



### Q24 • Convex Mirror Image Location

Page: 14

When drawing a ray diagram for a convex mirror, where is the image always located?



- a) Between F and C in front of the mirror
- b) Beyond C in front of the mirror
- c) At the focal point in front of the mirror

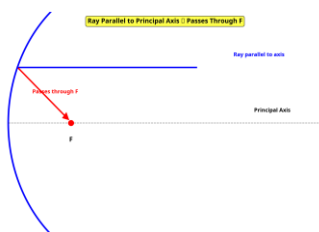
**d) Behind the mirror**



### Q25 • Concave Mirror - Ray Pallel to Principal Axis

Page: 14

In a ray diagram for a concave mirror with the object placed beyond C, one ray is drawn parallel to the principal axis. After reflection, this ray:



- a) Reflects back parallel to the principal axis
- b) Appears to come from the focal point (F)
- c) Passes through the focal point (F)**
- d) Passes through the center of curvature (C)

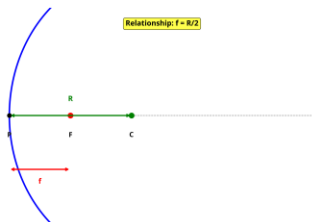
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## Q26 • Focal Length and Radius

Page: 15

What is the relationship between focal length ( $f$ ) and radius of curvature ( $R$ ) for a spherical mirror?



a)  $f = R$

**b)  $f = R/2$**

c)  $f = 2R$

d)  $f = R/4$

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### Q27 • Mirror Equation - Object at 36 cm

Page: 16

You place an object 36.0 cm in front of a concave mirror with a 16.0-cm focal length. Determine the image position.



a) 14.4 cm

b) 20.0 cm

**c) 28.8 cm**

d) 32.0 cm

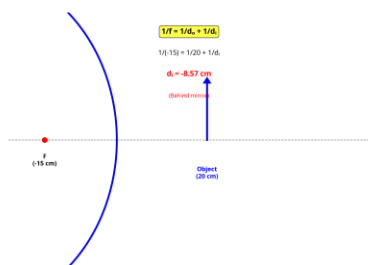
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### Q28 • Mirror Equation - Convex Mirror

Page: 16

You place an object 20.0 cm in front of a convex mirror with a  $-15.0$ -cm focal length. Find the image position.



a)  $-30.0$  cm

b)  $-12.0$  cm

c)  $-8.57$  cm

d)  $-6.0$  cm

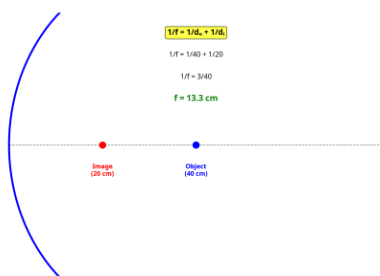
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### Q29 • Focal Length Calculation

Page: 17

An object at 40 cm from a concave mirror forms an image at 20 cm. What is the focal length?



a) 10 cm

**b) 13.3 cm**

c) 15 cm

d) 20 cm

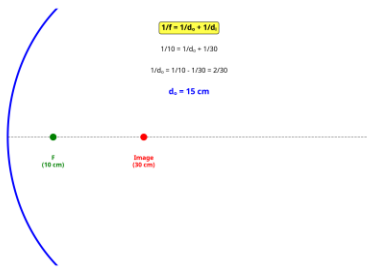
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### Q30 • Object Distance Calculation

Page: 17

A concave mirror with  $f = 10$  cm forms an image at 30 cm.  
Where is the object?



a) 10 cm

**b) 15 cm**

c) 20 cm

d) 25 cm

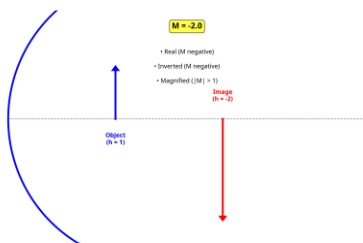
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### Q31 • Magnification of -2.0

Page: 18

A spherical mirror produces an image with a magnification of -2.0. What can be concluded about the image?



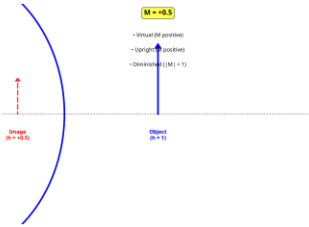
- a) Virtual, upright, and diminished
- b) Virtual, upright, and magnified
- c) Real, inverted, and diminished

**d) Real, inverted, and magnified**

### Q32 • Magnification of +0.5

Page: 18

What does a magnification value of +0.5 indicate about the image?



a) Real, inverted, and twice the size of the object

**b) Virtual, upright, and half the size of the object**

c) Real, upright, and half the size of the object

d) Virtual, inverted, and twice the size of the object

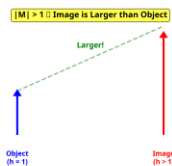
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### Q33 • Magnification Greater than 1

Page: 19

If the magnification ( $m$ ) is greater than 1, what does this indicate about the image?



- a) The image is inverted
- b) The image is smaller than the object
- c) The image is larger than the object**
- d) The image is virtual

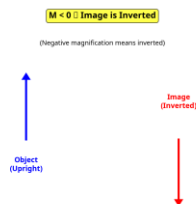
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### Q34 • Negative Magnification

Page: 19

What does a negative magnification ( $m$ ) value signify about the image orientation?



a) The image is upright

b) The image is virtual

**c) The image is inverted**

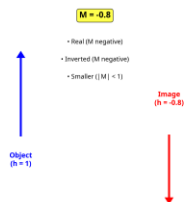
d) The image is smaller than the object



### Q35 • Magnification of -0.8

Page: 20

An optical system forms an image with a magnification of -0.8. Which statement correctly describes the image?



- a) The image is virtual and larger than the object
- b) The image is real and smaller than the object**
- c) The image is virtual and inverted
- d) The image is real and upright

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**Q36 • Mirror Type for Real Enlarged Image**

**Page: 21**

Which type of mirror can form a real, inverted image that is larger than the object?

a) Plane mirror

**b) Concave mirror**

c) Convex mirror

d) Both b and c

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### Q37 • Mirror Type for Same Size Image

Page: 21

For which mirror type is the image always virtual, upright, and the same size as the object?

**a) Plane mirror**

b) Concave mirror

c) Convex mirror

d) Both a and c

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### Q38 • Convex Mirror Applications

Page: 22

Which application commonly uses convex mirrors?

a) Makeup mirrors

**b) Vehicle side mirrors**

c) Telescopes

d) Solar furnaces

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### Q39 • Concave Mirror Applications

Page: 22

Which of the following uses a concave mirror?

- a) Vehicle side mirrors
- b) Security mirrors in stores
- c) Flashlights and headlights**
- d) Wide-angle surveillance

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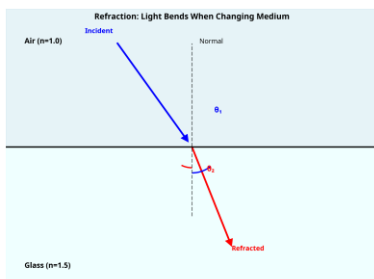
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## Q40 • Best Description of Refraction

Page: 23

What is the best description of refraction?



a) The bouncing of light off a surface

**b) The bending of light as it passes from one medium to another**

c) The spreading of light around obstacles

d) The change in light's speed in a vacuum

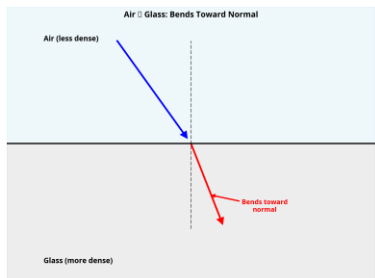
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### Q41 • Light from Air to Glass

Page: 23

In a ray diagram showing light passing from air into glass, how does the ray behave at the boundary?



- a) It bends away from the normal
- b) It bends toward the normal**
- c) It continues straight without bending
- d) It reflects back into the air

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### Q42 • Light from Glass to Air

Page: 24

When light passes from glass to air, what happens to the ray?



- a) Bends toward the normal
- b) Bends away from the normal**
- c) No bending occurs
- d) Total reflection always occurs

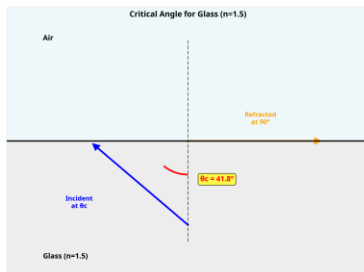
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### Q43 • Critical Angle

Page: 24

What is the critical angle for light traveling from glass ( $n=1.5$ ) to air ( $n=1.0$ )?



a)  $30^\circ$

**b)  $41.8^\circ$**

c)  $48.6^\circ$

d)  $53.1^\circ$

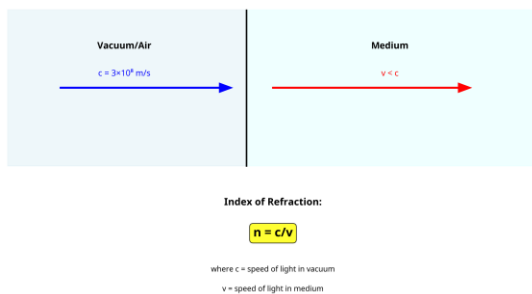
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#### Q44 • Index of Refraction Definition

Page: 25

The index of refraction ( $n$ ) is defined as:



a)  $n = v/c$

**b)  $n = c/v$**

c)  $n = \lambda/f$

d)  $n = f/\lambda$

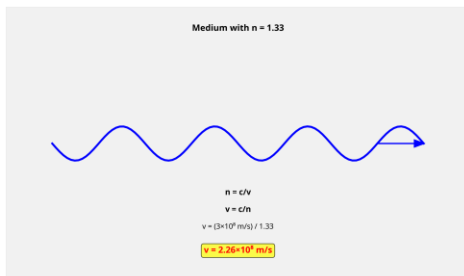
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### Q45 • Speed of Light in Medium

Page: 25

If the index of refraction of water is 1.33, what is the speed of light in water?



a)  $1.5 \times 10^8 \text{ m/s}$

b)  $2.0 \times 10^8 \text{ m/s}$

**c)  $2.26 \times 10^8 \text{ m/s}$**

d)  $3.0 \times 10^8 \text{ m/s}$

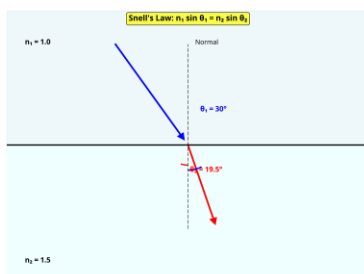
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### Q46 • Snell's Law Application

Page: 26

Light travels from air ( $n=1.0$ ) into glass ( $n=1.5$ ) at  $30^\circ$  to the normal. What is the angle of refraction?



a)  $15^\circ$

**b)  $19.5^\circ$**

c)  $22.5^\circ$

d)  $30^\circ$

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## Q47 • Total Internal Reflection

Page: 26

Total internal reflection occurs when:

- a) Light travels from less dense to more dense medium
- b) Light travels from more dense to less dense medium at angle  $>$  critical angle**
- c) Light strikes at normal incidence
- d) Light frequency is very high

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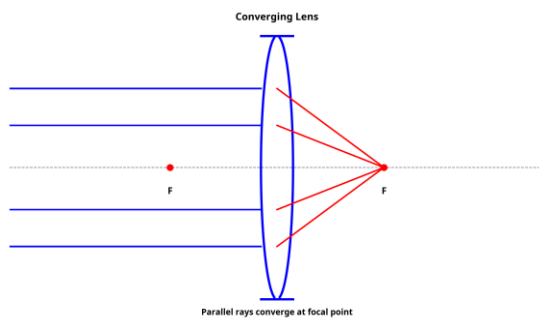
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### Q48 • Converging Lens Focal Point

Page: 27

For a converging lens, parallel rays:



a) Diverge after passing through

**b) Converge at the focal point**

c) Pass through unchanged

d) Are totally reflected

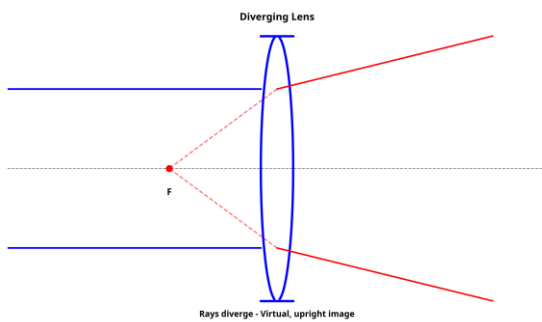
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### Q49 • Diverging Lens Image

Page: 27

A diverging lens always forms an image that is:



- a) Real and inverted
- b) Real and upright
- c) Virtual and inverted
- d) Virtual and upright**

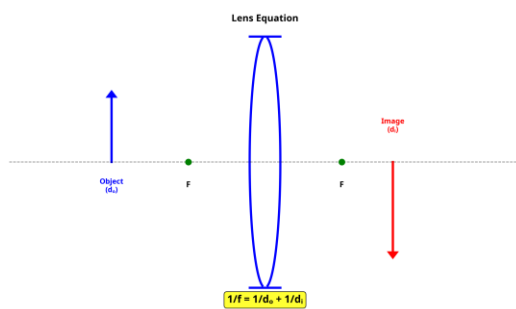
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## Q50 • Lens Equation

Page: 28

The thin lens equation is:



a)  $1/f = 1/d_o - 1/d_i$

**b)  $1/f = 1/d_o + 1/d_i$**

c)  $f = d_o + d_i$

d)  $f = d_o - d_i$

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## Physics Problems and Solutions

### Page 33

**Topic 21:** Understanding light from a point source.

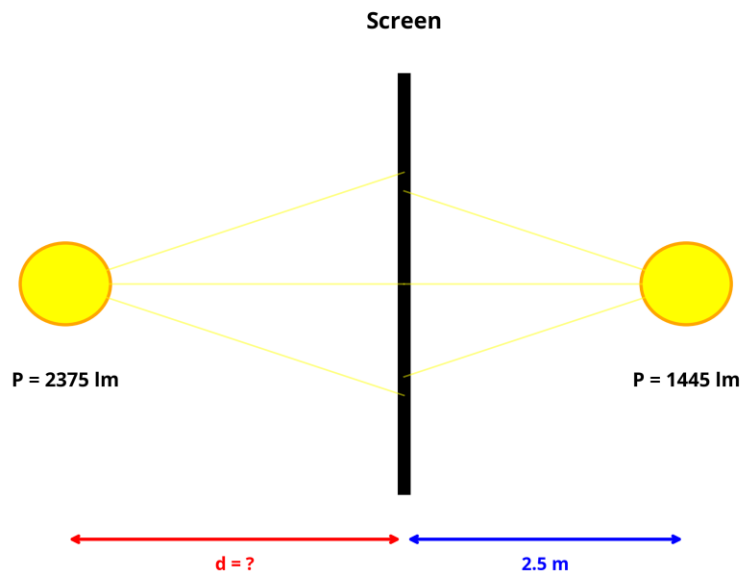
#### Q1:

A screen is placed between two lamps that light it up equally. The first lamp has a luminous flux of 1445 lm and is 2.5 m from the screen. If the second lamp has a luminous flux of 2375 lm, what is its distance from the screen?

**Answer:** The second lamp is approximately **3.21 meters** away from the screen. Because both lamps illuminate the screen equally, we can use the physics formula that connects a lamp's brightness (luminous flux) and its distance to the screen. By setting the illumination from both lamps as equal, we can calculate the unknown distance for the second lamp.



### Q1: Two Lamps Illuminating a Screen Equally

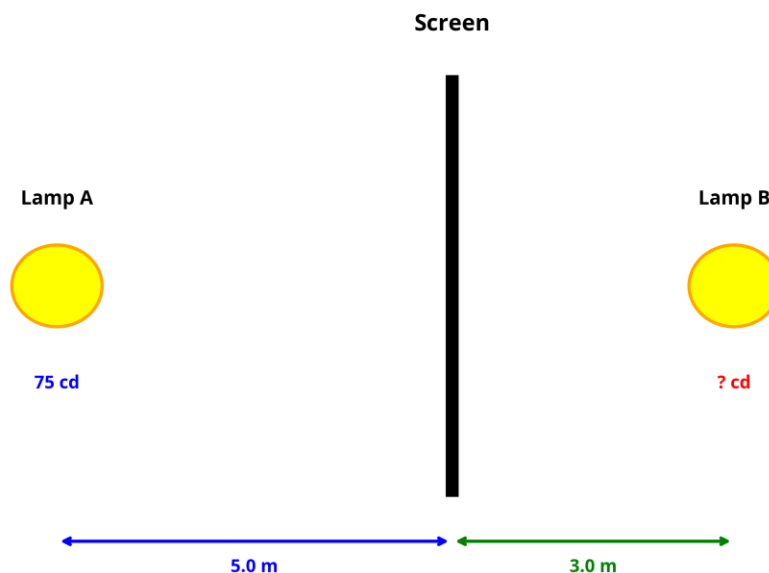


### Q2:

Two lamps light up a screen equally. Lamp A is 5.0 m away and is rated at 75 cd. If Lamp B is 3.0 m away, what is its rating in cd?



### Q2: Two Lamps at Different Distances



**Answer:** Lamp B is rated at **27 cd**. Since the screen is lit equally by both lamps, the illuminance from each is the same. Using the formula that relates a lamp's intensity (in candela) to its distance, we can determine the rating of Lamp B.

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#### Q3:

A 64-cd point source of light is 3.0 m away from a painting. What is the illumination on the painting in lux?

**Answer:** The illumination on the painting is approximately **7.11 lux**. This is calculated by dividing the intensity of the light source (64 cd) by the square of its distance from the painting (3.0 m).



#### Q4:

An experiment is set up with a lamp and a movable screen to study how the distance from the lamp affects the illumination on the screen. As the screen moves farther away, the light spreads over a larger area, and the illumination decreases.

**A-** On a grid where each square represents one unit of area, shade the area that receives the same amount of light as a single unit area when the screen is 4 meters from the lamp.

**Answer:** When the distance is 4 meters, the light has spread out. To find the equivalent area, you would shade a total of **16 squares** on the grid. This represents how the light intensity decreases as the square of the distance increases.

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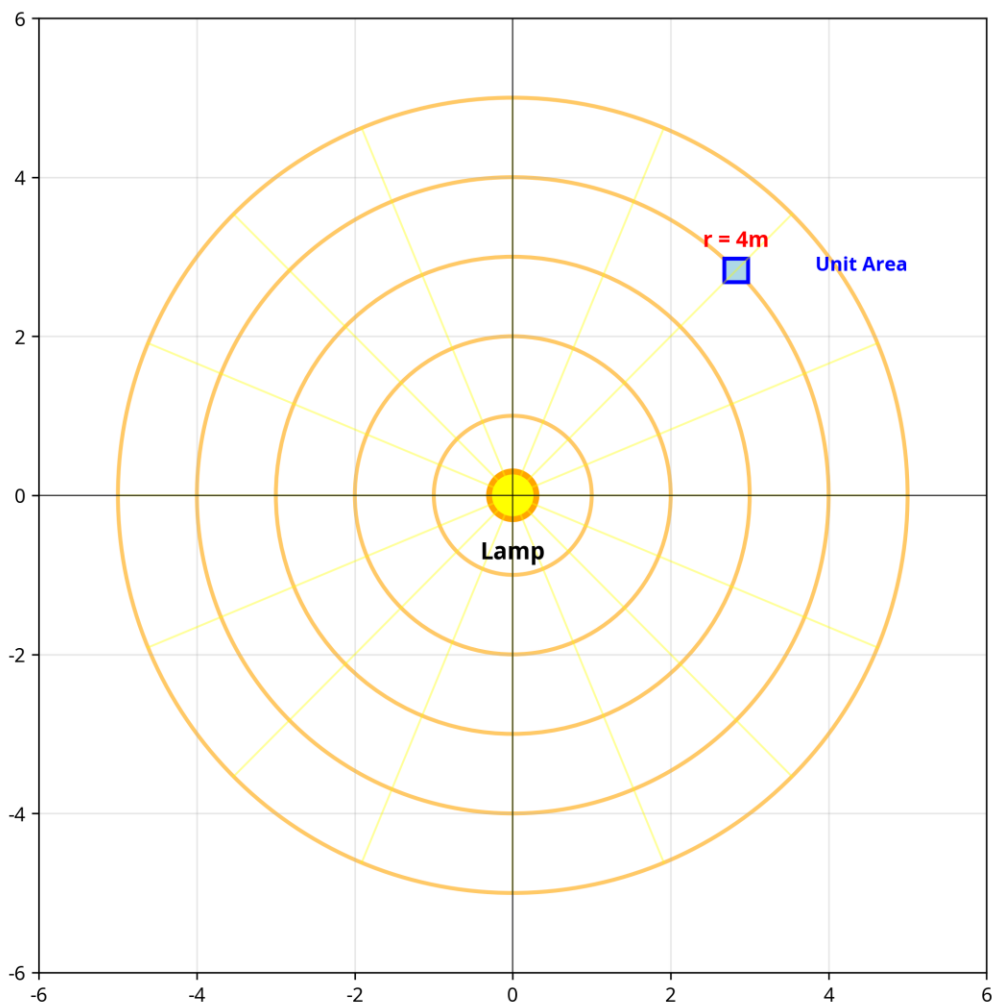
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**B-** If the illuminance from a lamp is 140 lx at a distance of 1 meter, what is the luminous flux of the lamp?



#### Q4: Light Spreading Over Spherical Surfaces

$$A = 4\pi r^2$$



**Answer:** The luminous flux of the lamp is approximately **1759 lumens (lm)**. We can calculate this by rearranging the formula that connects illuminance, distance, and luminous flux.



### Q5:

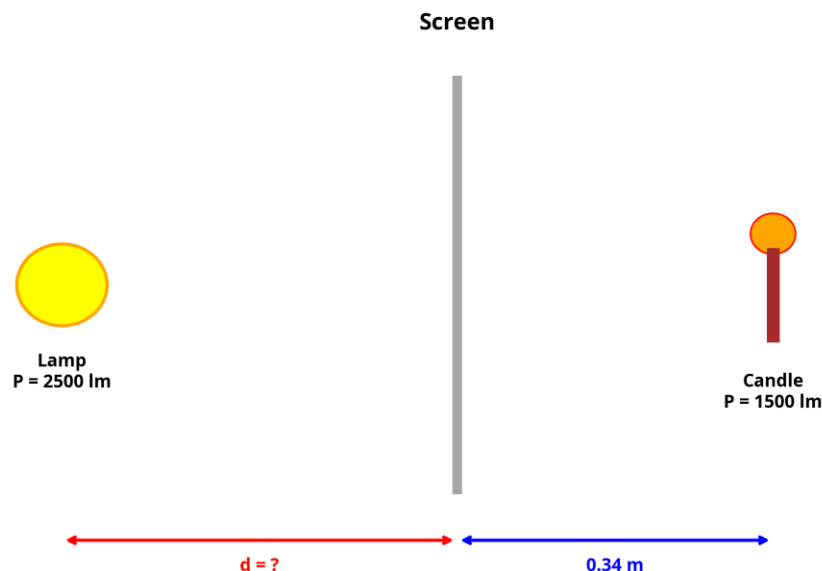
A candle with a luminous flux of 1500 lm is 0.34 m from a screen. It produces the same illumination as a lamp with a luminous flux of 2500 lm at an unknown distance (d).

**A-** Find the distance of the lamp from the screen (d).

**Answer:** The distance of the lamp from the screen is approximately **0.44 meters**. Since the illumination from both the candle and the lamp is equal, we can set their illumination formulas equal to each other and solve for the unknown distance.

**B-** If the lamp is moved closer to the screen to a new distance of 0.31 m, what is the ratio of the new illuminance to the old illuminance?

### Q5: Candle and Lamp Producing Equal Illumination



**Answer:** The ratio of the new illuminance to the old illuminance is approximately **2.02**. This means the screen is now about twice as bright as it was before the lamp was moved.



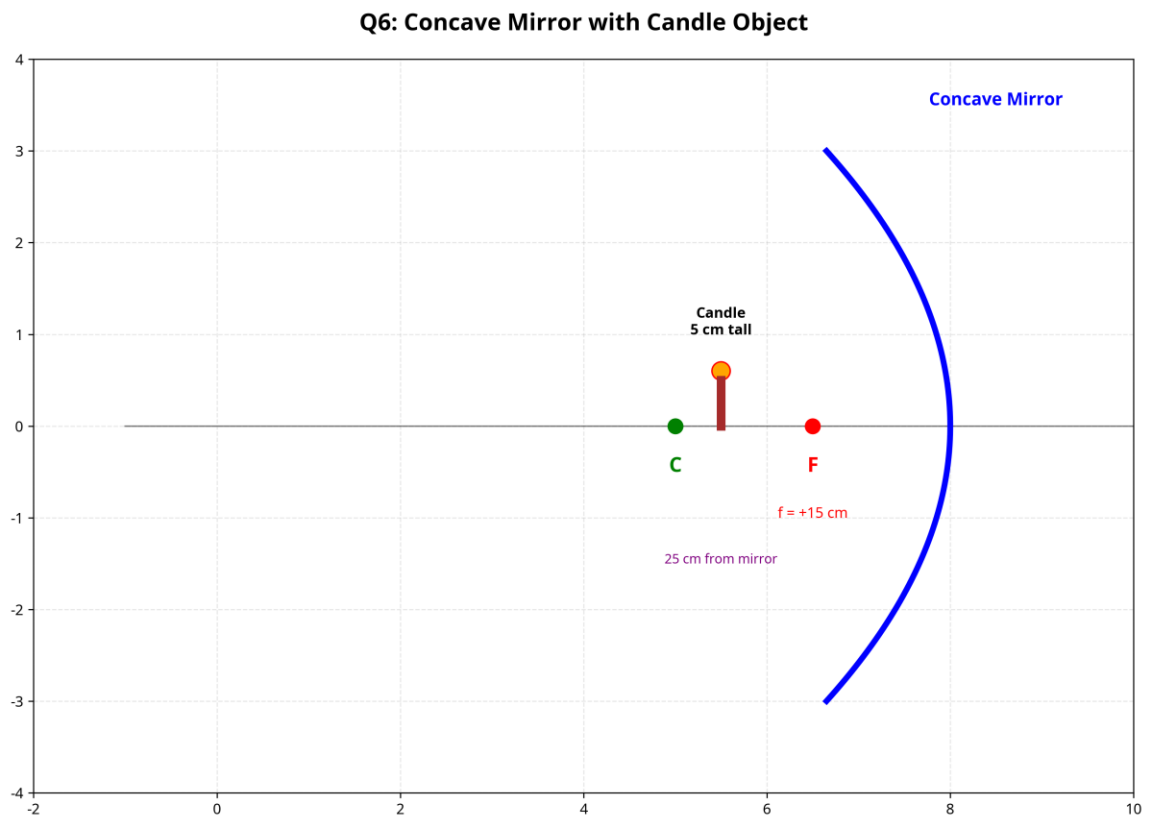
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**Topic 22:** Using ray diagrams and equations for curved mirrors.

**Q6:**

A curved mirror has a focal length of +15 cm. A 5 cm tall candle is placed 25 cm in front of it.

a) **What type of mirror is it, and what is its radius of curvature?**



**Answer:** - The mirror is a **concave mirror** because it has a positive focal length. - Its radius of curvature is **30 cm**, which is double the focal length.



### **b) Where is the image located?**

**Answer:** The image is located at **37.5 cm** from the mirror. This is found using the mirror equation, which relates the object distance, image distance, and focal length.

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### **c) What is the magnification of the image?**

**Answer:** The magnification is **-1.5**. The negative sign indicates that the image is inverted (upside down).

### **d) Draw the ray diagram for the image.**

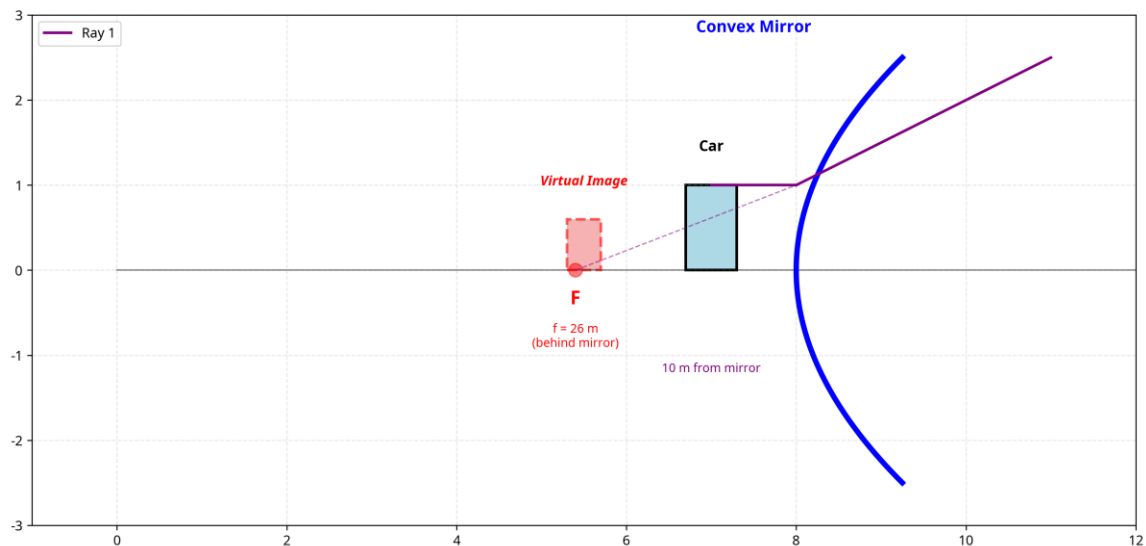
**Answer:** To draw the image, you would draw two main rays from the top of the candle: 1. A ray that travels parallel to the main axis and reflects through the focal point (F). 2. A ray that passes through the focal point (F) and reflects parallel to the main axis. The point where these two reflected rays cross is where the top of the inverted image will be.



**Q7:**

A car is 10.0 m away from a convex mirror that has a focal length of 26.0 m. How far behind the mirror does the image of the car appear?

**Q7: Convex Mirror - Car Image Formation**



**Answer:** The image of the car appears approximately **7.22 meters** behind the mirror. For a convex mirror, the focal length is negative. Using the mirror equation, we can calculate the image distance, which will also be negative, confirming it's a virtual image behind the mirror.

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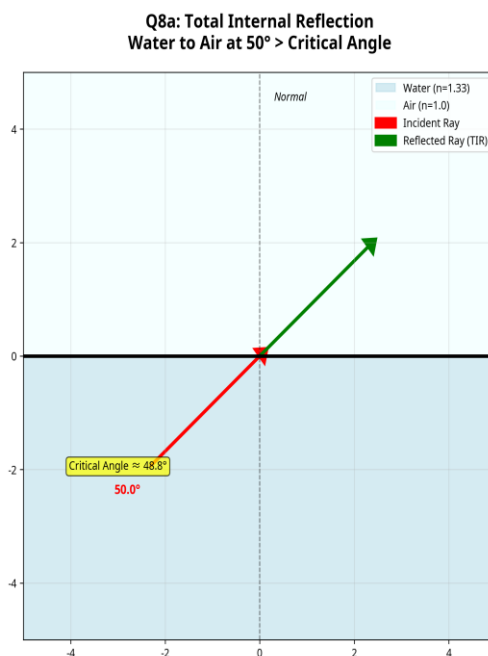
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**Topic 23:** Understanding the refraction of light.



**Q8:**

- a) What happens when a ray of light traveling from water ( $n=1.33$ ) into air ( $n=1.0$ ) strikes the surface at an angle of  $50.0^\circ$ ?

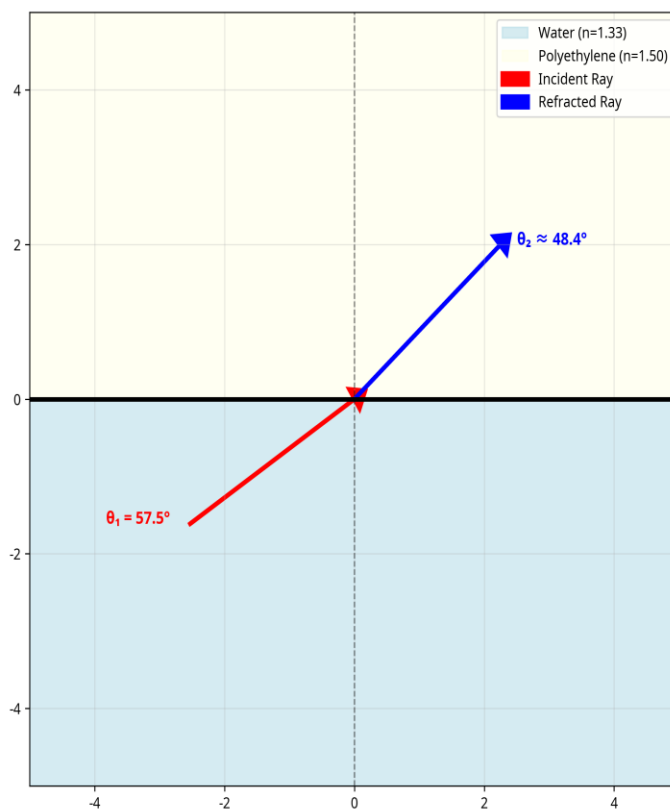


**Answer:** The light ray will be **totally internally reflected**. This happens because the light is moving from a denser medium (water) to a less dense medium (air), and the angle at which it strikes the surface ( $50.0^\circ$ ) is greater than the critical angle (which is about  $48.8^\circ$  for water-to-air).

- b) A beam of light passes from water ( $n=1.33$ ) into polyethylene ( $n=1.50$ ) at an angle of  $57.5^\circ$ . What is the angle of refraction in the polyethylene?



Q8b: Refraction from Water to Polyethylene



**Answer:** The angle of refraction in the polyethylene is approximately  $49.4^\circ$ . This is calculated using Snell's Law, which describes how light bends when it passes from one material to another.

### c) What is the speed of light in chloroform ( $n=1.51$ )?

**Answer:** The speed of light in chloroform is approximately  $1.99 \times 10^8$  m/s. This is found by dividing the speed of light in a vacuum (about  $3.00 \times 10^8$  m/s) by the refractive index of chloroform.

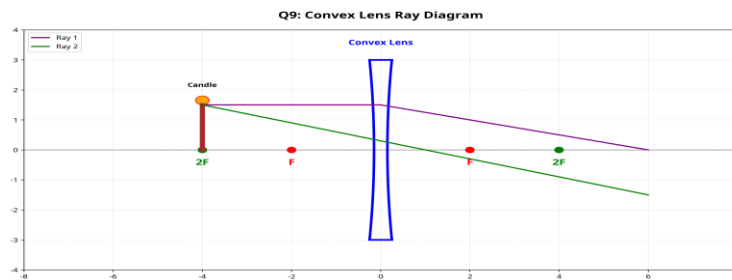


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**Topic 24:** Using ray diagrams and equations for lenses.

**Q9:**

The figure shows a candle in front of a convex lens. Draw the resulting image.



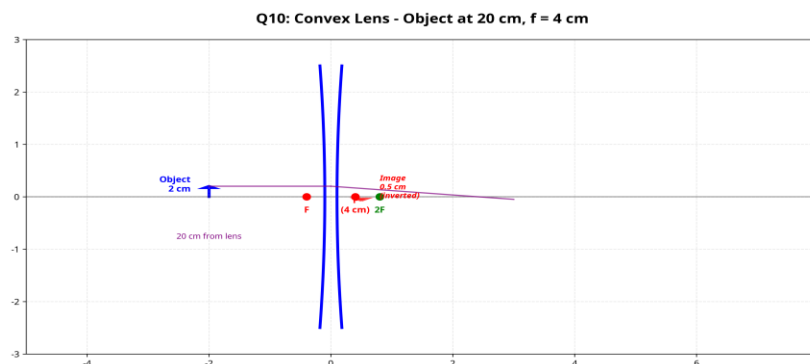
**Answer:** To find the image, you draw two rays from the top of the candle: 1. A ray that travels parallel to the main axis and, after passing through the lens, bends to go through the focal point (F) on the other side. 2. A ray that passes through the center of the lens and continues in a straight line without bending. The point where these two rays intersect on the other side of the lens is where the top of the image is formed.



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### Q10:

An object is placed 20.0 cm from a convex lens that has a focal length of 4.0 cm.



### a) Where is the image?

**Answer:** The image is located at **5.0 cm** from the lens on the opposite side. This is calculated using the thin lens equation, which relates the object distance, image distance, and focal length.

### b) If the object is 2.0 cm high, how tall is the image?

**Answer:** The image is **0.5 cm** tall. The height of the image can be found using the magnification formula, which relates the image and object heights to their respective distances from the lens.

### c) What is the orientation of the image?

**Answer:** The image is **inverted** (upside down). We know this because the magnification value is negative.



### d) What is the magnification produced by the lens?

**Answer:** The magnification is **-0.25**. The negative sign confirms that the image is inverted, and the value of 0.25 indicates that the image is smaller than the object (it is one-quarter of the object's size).

| المفهوم                             | الصيغة الرياضية                                      | المتغيرات                                                                                               | ملاحظات                                                       |
|-------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| قانون التربيع العكسي للاستضاءة      | $E \propto \frac{1}{r^2}$                            | المسافة: $r$ ، الاستضاءة: $E$ (Lux) (m)                                                                 | يصف العلاقة بين الاستضاءة والمسافة من مصدر ضوئي نقطي.         |
| حساب الاستضاءة                      | $E = \frac{P}{4\pi r^2}$                             | التدفق: $P$ ، الاستضاءة: $E$ (Lux) (m) المسافة: $r$ ، الشدة الضوئية (lm)                                | صيغة حساب الاستضاءة من مصدر ضوئي نقطي.                        |
| قانون مالوس (شدة الضوء المستقطب)    | $I = I_0 \cos^2 \theta$                              | الشدة الأولية: $I_0$ ، الشدة النهائية: $I$ ، الزاوية بين المحورين: $\theta$                             | لحساب شدة الضوء بعد مروره بمحلل (Analyzer).                   |
| زاوية بروستر (الاستقطاب بالانعكاس)  | $\tan \theta_p = n$                                  | معامل: $n$ ، زاوية بروستر: $\theta_p$ الانكسار                                                          | لحساب زاوية السقوط التي يحدث عندها استقطاب كلي للضوء المنعكس. |
| الانزياح دوبلري (للضوء)             | $\frac{\Delta \lambda}{\lambda} \approx \frac{v}{c}$ | $\Delta \lambda$ : التغير في الطول الموجي، سرعة: $v$ ، الطول الموجي الأصلي، سرعة الضوء: $c$ ، المصدر،   | يستخدم لحساب سرعة الأجسام الفلكية (الانزياح الأحمر/الأزرق).   |
| العلاقة بين البعد البؤري ونصف القطر | $f = \frac{R}{2}$                                    | نصف قطر: $R$ ، البعد البؤري: $f$ ، التكرور                                                              | العلاقة بين البعد البؤري ومركز التكرور للمرايا الكروية.       |
| معادلة المرايا (أو الرقيقة العدسات) | $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$        | مسافة الجسم: $d_o$ ، البعد البؤري: $f$ ، مسافة الصورة: $d_i$                                            | ترابط بين البعد البؤري ومسافتي الجسم والصورة.                 |
| التكبير                             | $m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$             | ارتفاع الصورة: $h_i$ ، التكبير: $m$ ، مسافة: $d_i$ ، ارتفاع الجسم: $h_o$ ، مسافة الجسم: $d_o$ ، الصورة، | لحساب مقدار واتجاه التكبير.                                   |



|                                         |                                         |                                                                                                                    |                                                         |
|-----------------------------------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| معامل الانكسار                          | $n = \frac{c}{v}$                       | سرعة $c$ : معامل الانكسار،<br>سرعة الضوء $v$ : الضوء في الفراغ،<br>في الوسط                                        | تعريف معامل الانكسار للوسط                              |
| قانون سنيل<br>للالانكسار                | $n_1 \sin \theta_1 = n_2 \sin \theta_2$ | معامل الانكسار للوسطين، $n_1, n_2$ :<br>زاوية $\theta_2$ : زاوية السقوط، $\theta_1$ :<br>الانكسار                  | يصف انحراف الضوء عند<br>مروره بين وسطين مختلفين         |
| الزاوية الحرجة                          | $\sin \theta_c = \frac{n_2}{n_1}$       | معامل $n_1$ : الزاوية الحرجة، $\theta_c$ :<br>$n_2$ : انكسار الوسط الأكبر كثافة،<br>معامل انكسار الوسط الأقل كثافة | لحساب الزاوية التي يبدأ عندها<br>الانعكاس الكلي الداخلي |
| قانون الانعكاس<br>(للموجات)             | $\theta_i = \theta_r$                   | زاوية $\theta_r$ : زاوية السقوط، $\theta_i$ :<br>الانعكاس                                                          | زاوية السقوط تساوي زاوية<br>الانعكاس                    |
| قانون حيود<br>الموجات (لشبكة<br>الحيود) | $d \sin \theta = m \lambda$             | زاوية $\theta$ : المسافة بين الشقوق، $d$ :<br>الطول $\lambda$ : رتبة الهدب، $m$ : الحيود،<br>الموجي                | يستخدم لحساب زوايا الحيود                               |