Geometric Optics: Refraction, Lenses & Mirrors

Geometric optics · 5 questions · step-by-step answers at the end

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USEFUL EQUATIONS

$n = c/v \quad n_1 \sin\theta_1 = n_2 \sin\theta_2 \quad 1/d_o + 1/d_i = 1/f \quad m = -d_i/d_o = h_i/h_o \quad f = R/2$

Questions

Show your working in the space under each question.

1. Light passes from water (n = 1.33) into air at 30° to the normal. Find the refraction angle and the critical angle.

2. An object is 30 cm from a converging lens with f = 10 cm. Locate and describe the image. Then repeat with the object 5.0 cm from the lens.

3. What is the speed of light in glass with n = 1.5?

4. Light passes from air into water. What happens to its frequency, speed and wavelength?

5. Why can a convex (diverging) mirror never form a real image?

Step-by-step answers

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1. $\sin\theta_2 = 1.33 \sin 30° = 0.665 \rightarrow \theta_2 \approx$ **42°**; critical angle $= \sin^{-1}(1/1.33) \approx$ **49°**.

2. 1. $1/d_i = 1/10 - 1/30 = 2/30 \rightarrow d_i =$ **+15 cm** (real, on the far side).
2. $m = -15/30 =$ **−0.50**: inverted and half size. This is how a camera works.
3. Object at 5.0 cm: $1/d_i = 1/10 - 1/5 = -1/10 \rightarrow d_i =$ **−10 cm** (virtual, same side as the object).
4. $m = -(-10)/5 =$ **+2.0**: upright and twice the size. This is a magnifying glass.

Answer: 30 cm → real, inverted, ×0.5 at 15 cm; 5 cm → virtual, upright, ×2 at −10 cm

3. $v = c/n =$ **2.0×10^8 m/s**.

4. Frequency **same**; speed and wavelength **decrease** by a factor of n.

5. Reflected rays always **spread out**; they only appear to meet behind the mirror.