InkPhysics

ANSWER BOOK

Lenses and images

Waves · Year 12

12 questions · 33 marks

NAVY EDITION

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SECTION A · Warm-up

A1 The principal focus is the point where rays arriving parallel to the principal axis are brought together after passing through the lens. The focal length is the distance from the centre of the lens to the principal focus. [2]

A2 f = 40 cm = 0.40 m. P = 1/f = 1/0.40 = 2.5 D (dioptres). [2]

A3 A real image is formed where rays actually meet, so it can be caught on a screen. A virtual image is formed where rays only appear to come from when projected backwards; no rays pass through it and no screen can catch it. [2]

SECTION B · Standard

B1 1/v = 1/f - 1/u = 1/0.15 - 1/0.45, so v = 0.225 m ≈ 0.23 m. m = v/u = 0.50. [3]

B2 A ray parallel to the principal axis refracts to pass through the principal focus on the far side. A ray through the centre of the lens continues undeviated. A ray passing through the near principal focus leaves the lens parallel to the axis. Any two fix the image; the third confirms it. [3]

B3 1/v = 1/0.25 - 1/0.10 = -6.0 m^{-1}, so v = -0.167 m ≈ -0.17 m. The negative sign means the image is virtual: upright and on the same side as the object. m = |v|/u = 1.67, so the image is magnified. [4]

B4 The whole image remains, but dimmer. Every point of the object sends rays through every part of the lens, so the uncovered half still forms the complete image with half the light. [2]

B5 f = 1/P = 1/(-4.0) = -0.25 m. The negative sign marks the lens as diverging: parallel rays spread as if from a focus 25 cm on the incoming side. [2]

SECTION C · Stretch

C1 1/f = 1/u + 1/v = 1/0.30 + 1/0.60 = 5.0 m^{-1}, so f = 0.20 m (20 cm). [3]

C2 Powers of thin lenses in contact add: P = 4.0 + (-1.5) = 2.5 D. f = 1/P = 1/2.5 = 0.40 m (converging). [3]

C3 $1/u = 1/f - 1/v = 1/0.050 - 1/3.0 = 19.67\ \text{m}^{-1}$, so $u = 0.0508$ m ≈ 5.1 cm. $m = v/u = 3.0/0.0508$ ≈ 59. [3]

C4 Inside the focal length the refracted rays diverge, so only their backward projections meet: the image is virtual, upright and magnified, which is what a magnifying glass is for. As the object approaches the focal point the projections meet further and further away and the image grows; at the focal point itself the rays emerge parallel and the image forms at infinity. [3]