

Reflection, refraction and images from mirrors and lenses

AP Physics 2 (algebra-based) · Test answers (mark scheme)

The marking guide awards marks for the right relationship, the substitution and the final answer with a unit or a clear description. Sign errors in the lens equation cost the mark for the value but not for the method.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 13

Question 1 Reflection (2 marks)

(a) $\theta_i = 90^\circ - 25^\circ = \mathbf{65^\circ}$.

(b) The reflected ray also makes 65° with the normal, so the angle between the rays is $2 \times 65^\circ = \mathbf{130^\circ}$.

Marking: 1 mark each part.

Question 2 Refraction into glass (3 marks)

(a) $v = c/n = 3.00 \times 10^8 / 1.60 = \mathbf{1.9 \times 10^8 \text{ m/s}}$.

(b) $\sin \theta_2 = \sin 50^\circ / 1.60 = 0.7660 / 1.60 = 0.4788$, so $\theta_2 = \mathbf{29^\circ}$.

Marking: (a) 1; (b) 1 for Snell's law substituted, 1 for the angle.

Question 3 Total internal reflection (3 marks)

(a) $\sin \theta_c = 1/1.55 = 0.645$, so $\theta_c = \mathbf{40.2^\circ}$.

(b) Light must travel from the denser medium to the less dense medium, and the angle of incidence must be greater than the critical angle.

Marking: (a) 1 for the equation, 1 for the angle; (b) 1 for both conditions.

Question 4 Image from a lens (4 marks)

(a) $1/d_i = 1/20 - 1/50 = 3/100$, so $d_i = \mathbf{33 \text{ cm}}$.

(b) $m = -d_i/d_o = -33.3 / 50 = \mathbf{-0.67}$.

(c) The image is real, inverted and reduced (3.3 cm tall).

Marking: (a) 1 for the substitution, 1 for the value; (b) 1; (c) 1.

Question 5 Convex mirror (3 marks)

(a) $1/d_i = -1/15 - 1/45 = -4/45$, so $d_i = -11 \text{ cm}$.

(b) The negative d_i means a **virtual** image. $m = +11.25 / 45 = +0.25$, so it is **upright** and reduced.

Marking: (a) 1 for the substitution, 1 for the value; (b) 1.

Question 6 Diverging lens (2 marks)

A diverging lens spreads the rays that pass through it, so they never meet on the other side. They only appear to come from a point on the object side, which makes the image virtual, whatever the object distance.

Marking: 1 for the diverging rays; 1 for virtual image.

Question 7 Bent pencil (2 marks)

Light from the part of the pencil under water bends away from the normal as it leaves the water into the air. The eye traces the rays back in straight lines, so the submerged part appears at a different position from the part in air, making the pencil look bent.

Marking: 1 for refraction away from the normal; 1 for tracing straight back.

Question 8 Sign convention (1 mark)

Both have a **positive** focal length.

Marking: 1 mark for both correct.