

Waves that add: fringes and grating spectra

Physics grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Model answers with a marking guide. Award method marks for correct rearrangement and substitution even if the final value is wrong, and check units and powers of ten.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB C.3

Question 1 Path difference (3 marks)

- a. $1.65 \times 10^{-6} \div 550 \times 10^{-9} = \mathbf{3 \lambda}$.
- b. A whole number of wavelengths, so **constructive**.
- c. Same frequency and a constant phase difference.

Marking: 1 mark for each part.

Question 2 Young double slit (3 marks)

- a. $w = \lambda D/s = 480 \times 10^{-9} \times 1.80 \div 0.20 \times 10^{-3} = \mathbf{4.32 \text{ mm}}$.
- b. The spacing halves.

Marking: (a) 1 for substitution, 1 for answer with unit; (b) 1.

Question 3 Grating at work (3 marks)

- a. $d = 4.00 \mu\text{m}$. $\sin \theta = 600 \times 10^{-9} \div 4.00 \times 10^{-6} = 0.15$, $\theta = \mathbf{8.63^\circ}$.
- b. $d/\lambda = 6.67$, so the highest order is **6**.

Marking: (a) 1 for $\sin \theta$, 1 for angle; (b) 1.

Question 4 Reading a pattern (3 marks)

- a. **3.0 mm**.
- b. $\lambda = ws/D = 3.0 \times 10^{-3} \times 0.40 \times 10^{-3} \div 2.0 = 0.000 \text{ m} = \mathbf{600 \text{ nm}}$.

Marking: (a) 1; (b) 1 for rearrangement/substitution, 1 for answer.

Question 5 Two torches (2 marks)

Atoms in a torch emit light in random bursts, so the phase difference between two torches changes constantly and no fixed bright or dark positions form. A laser beam divided by the two slits gives two sources derived from the same wave, so their **phase difference stays**

constant and a stable pattern forms.

Marking: 1 for random phase from separate sources; 1 for constant phase difference from the same wavefront.

Question 6 White light fringes (2 marks)

The central fringe is **white** because every wavelength has zero path difference there. Other fringes are coloured spectra because $w = \lambda D/s$ differs for each colour; violet (shortest λ) is nearest the centre and red is furthest.

Marking: 1 for white centre with reason; 1 for coloured fringes with violet inside and red outside.

Question 7 Fringes in water (2 marks)

In water the wavelength is $\lambda \div 1.33$, so w also falls by 1.33: $w = 4.0 \div 1.33 = \mathbf{3.01 \text{ mm}}$.

Marking: 1 for wavelength reduced by n ; 1 for the new value.

Question 8 Grating versus two slits (2 marks)

Many slits all contribute, so the waves are in step only at the exact grating angles. At other angles the large number of waves with different phases cancel almost exactly. More light is also transmitted in total, so **the maxima are narrow and bright**.

Marking: 1 for cancellation almost everywhere; 1 for narrow and bright maxima.